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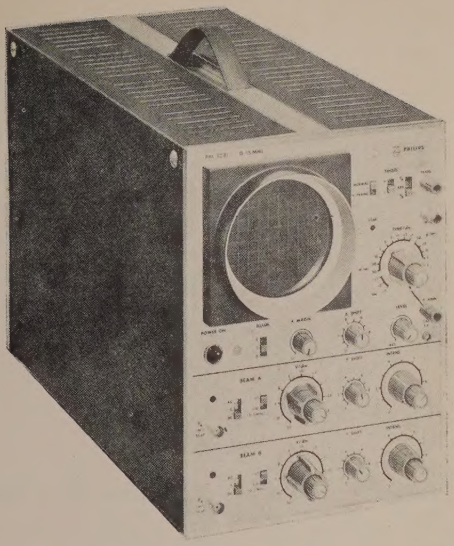

PHILIPS

Manual

DOUBLE-BEAM OSCILLOSCOPE

PM 3231

9444 032 31 . . 1

#4342

9499 440 06111

15/469/02/03

IMPORTANT

In correspondence concerning this instrument, please quote the type number and serial number as given on the type plate at the bottom of the instrument.

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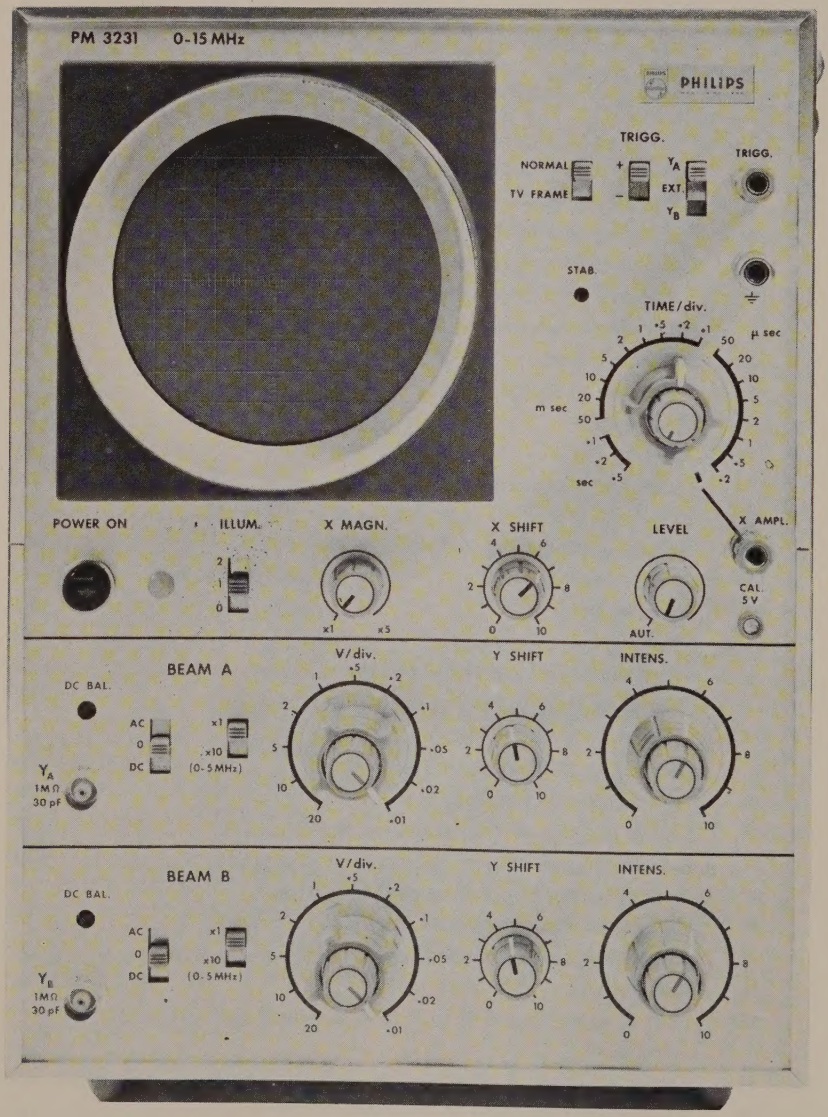


Fig. 1. Front view

GENERAL INFORMATION

1 *Introduction*

The double-beam oscilloscope PM 3231 has been equipped with a cathode-ray tube having two electron guns. The screen of this tube has been provided with metal-backed phosphor, so that a high brilliance and a sharp spot are obtained.

Focusing and brightness of the two beams can be adjusted independent of each other.

The two identical vertical amplifiers, the horizontal amplifier and the time base generator are fully transistorised.

The input stages use field effect transistors, so that high input impedances are obtained.

Zero line locking is obtained by means of drift feedback.

The instrument incorporates two signal delay lines.

II *Technical data*

Vertical amplifiers

Frequency range	Position "x1": – in position DC of the selector : 0 Hz... 15 MHz (–3 dB) – in position AC of the selector : 2 Hz... 15 MHz (–3 dB) Rise time : 23 ns Position "x10": – in position DC of the selector : 0 Hz... 5 MHz (–3 dB) – in position AC of the selector : 2 Hz... 5 MHz (–3 dB) Rise time : 70 ns
Deflection coefficient	Position "x1": 10 mV per division up to 20 V per division, in 11 calibrated steps (sequence 1, 2, 5) Position "x10": in this position the max. sensitivity is increased to 1 mV per division. Continuous control of the coefficients between the steps is possible (non-calibrated).
Effective signal delay	$\geqslant$ 50 ns
Measuring error	in position "x1" : 3 % in position "x10": 4 %
Input impedance	1 MΩ//30 pF
Max. input voltage	500 V (direct voltage + peak value of the alternating voltage)
Max. deflection	For sinewave signals with frequencies up to 1 MHz the vertical deflection is undistorted for a total amplitude of 24 divisions. With the aid of the "Y SHIFT" controls the peaks of the signal can be displayed.
Balance controls	Balance controls have been provided on the front panel for correction of the d.c. balance in the first amplifier stages.

D.C. drift	Smaller than 1 division per hour at constant ambient temperature.
Calibration voltage	For adjusting the sensitivity of the vertical amplifiers and the squarewave response of the measuring probes a squarewave voltage is available at a socket on the front panel. The amplitude is 5 V_{p-p} $\pm$ 1 % and the frequency is approx. 2.5 kHz.
Time base generator	
Time coefficient	0.2 µs per division up to 0.5 s per division, in 20 calibrated steps (sequence 1, 2, 5) Continuous control of the coefficients between the steps is possible (not calibrated).
Measuring error	$<$ 5 %
Expansion	The horizontal deflection can be expanded up to 5 times (50 divisions) by a non-calibrated continuous control. At maximum expansion the extremities of the time base line can be displayed with the X SHIFT control. At maximum expansion the highest sweep time is 40 ns per division and the accuracy of the sweep times is $\pm$ 10 %.
Sawtooth voltage	A sawtooth voltage of 8 V_{p-p} is available at a socket on the rear of the instrument.
Triggering	
Trigger mode	Automatic triggering. In the absence of a trigger signal the time base generator starts free-running and a sharp line is displayed. Triggering with continuously adjustable level on the positive or negative-going edges of the trigger. signal.
Trigger level	Continuously adjustable over 8 divisions for internal triggering and 10 V_{p-p} for external triggering.
Trigger source	Internal, from one of the vertical amplifiers or external. The external trigger input is d.c. coupled.

Trigger input impedance — 1 MΩ//10 pF

Trigger sensitivity — The following table indicates the minimum values at which stable triggering is guaranteed.

Stability control — The trigger stability control, which hardly ever requires readjustment, is located on the front panel and can be operated by means of a screwdriver.

Trigger source	*Trigger mode*	*Reference values for sinewave signals (Normal)*			*T.V. signals (T.V. frame)*
		0 Hz ... 10 Hz	10 Hz ... 5 MHz	5 MHz ... 15 MHz	
internal	auto		2 divisions	4 divisions	
	level		0.5 divisions	4 divisions	1 division
external	auto		2 V_{p-p}	2 V_{p-p}	
	level	1 V_{p-p}	1 V_{p-p}	1 V_{p-p}	1 V_{p-p}

Max. trigger input voltage — 500 V (d.c. voltage + peak value of alternating voltage). Protected against over-voltage.

Horizontal amplifier

Frequency range — 0 Hz... 2 MHz (–3 dB) with control "X MAGN" in position "x1"

Deflection coefficient — Continuously adjustable between 200 mV per division and 1 V per division.

Input impedance — 50 kΩ//60 pF

Maximum input voltage — 50 V continuously permissible. Protected against over-voltage.

Maximum deflection — For sinewave signals with frequencies up to 500 kHz the horizontal deflection is undistorted, for a total amplitude of 50 divisions. Any 10 divisions can be displayed on the screen.

Power supply

Mains voltages	94... 127 V (110 V nominal) or 187... 253 V (220 V nominal) a.c.
Mains frequencies	50... 400 Hz
Power consumption	80 W

A storage compartment for the mains cable has been provided.

Cathode-ray tube

Sort of tube	10 cm tube with acceleration voltage of 4 kV.
Type of tube	E10 - 130 GP
Effective screen area	Up to 8 divisions in the vertical direction and up to 10 divisions in the horizontal direction for both beams. One division is 8 mm.
Max. angle between the horizontal axes in the screen centre	0.6°
Screen type	GP (P2), medium short persistence, bluish-green. Types GH (P31) and GM (P7) are available
Brilliance and focusing	Controls have been provided for both beams on the front panel.
Beam control	The unblanking during the sweep is achieved by beam deflection and is D.C. coupled.
Beam modulation	External Z modulation is possible via the Wehnelt cylinder of each electron gun. An input to each gun is available at the rear panel of the instrument. The voltage required for brightness modulation is 15 V_{p-p} for frequencies between 10 Hz and 1 MHz. Input impedance 1 MΩ//50 pF.
Graticule illumination	Three fixed levels for simple camera settings.
Effect of mains voltage variations of ± 15 %	The deflection and time coefficients vary max. 2 %.

Operating conditions The tolerances stated apply at an ambient temperature between –10° C and +45° C.

Dimensions and weight

Height	30 cm (11¾")
Length	45 cm (18")
Width	21 cm (8¼")
Weight	11 kg (24 lbs)

Note

Properties expressed in numerical values with tolerances stated are guaranteed by the factory. Numerical values without tolerances indicate the properties of an average instrument and merely serve as a guide. All data apply at nominal mains voltage, unless otherwise stated.

III *Accessories*

Supplied with the instrument are:

A manual
Two BNC to 4-mm banana-plug adapters PM 9051
A plastic dust cover

Optional accessories

Probe set; probe cable 1.15 m (3¾')	: PM9326
Probe set; probe cable 2 m (6½')	: PM9327
Rubber viewing hood	: PM9370
Carrying case	: PM9303

Fig. 2. Probe set PM 9327

IV *Description of the block diagram* (Fig. 3)

Vertical amplifiers

The oscilloscope has two identical vertical d.c. amplifiers, so that two signals can be displayed at the same time.

Each vertical amplifier consists of:

- a step attenuator, by means of which the amplitude of the signal on the screen can be controlled in calibrated steps.
- an input stage, by means of which a high input impedance is obtained
- a pre-amplifier with drift feedback
- a delay line, by means of which the leading edges of fast phenomena can be displayed
- a driver stage for the delay line
- an output stage

Trigger amplifier

The trigger amplifier amplifies the trigger signal derived from the vertical amplifiers or from an external voltage source.
The polarity of the trigger signal and the trigger level are adjustable.

Trigger pulse shaper

The trigger pulse shaper supplies well defined trigger pulses for starting the time base generator.
The trigger unit also comprises a synchronisation separator for T.V. signals, so that triggering by means of these signals is also possible.

Time base generator

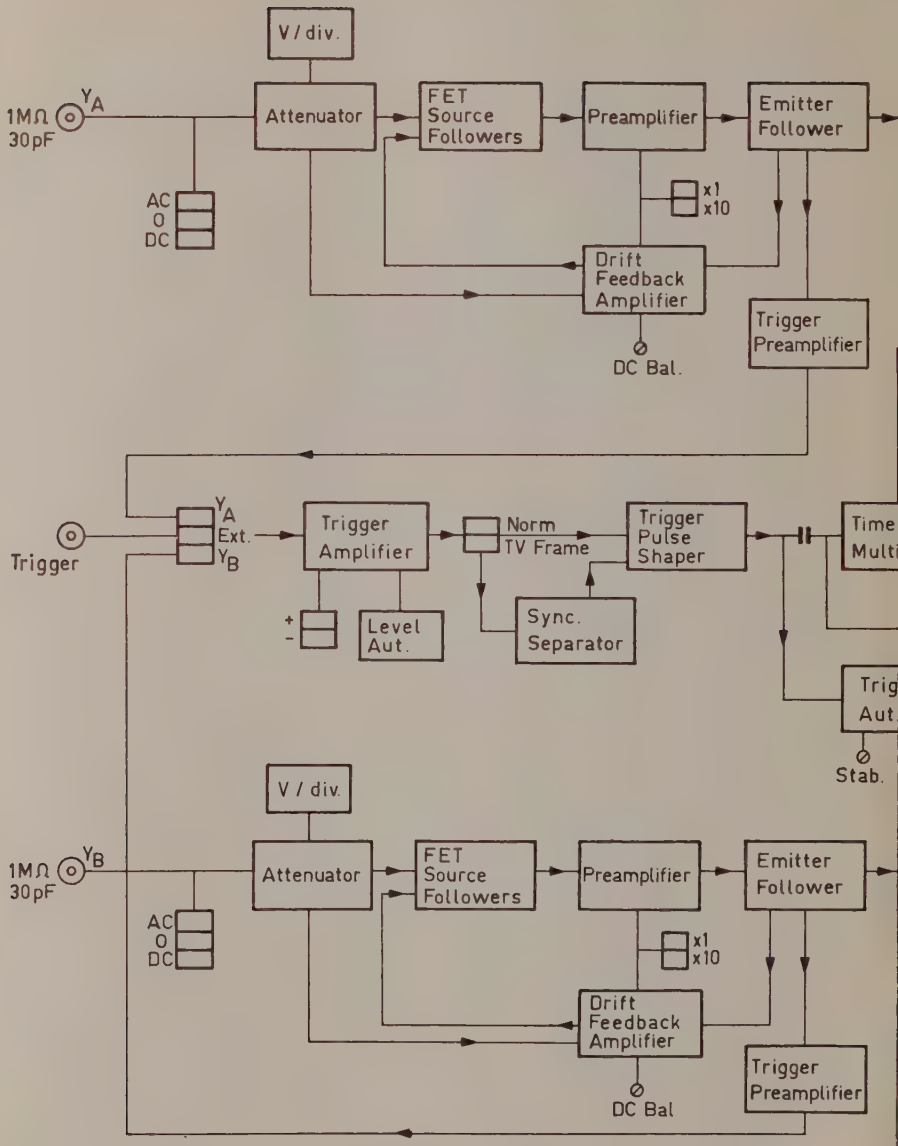
The time base generator is of the Bootstrap integrator type.
The generator comprises the charging capacitors and resistors which are selected with switch TIME/div.
Continuous control of the time coefficient is effected with potentiometer TIME/div.
The stability of the time base generator can be controlled with screwdriver control STAB.
The sawtooth voltage is externally available at output socket TIME BASE.

X-amplifier

The X-amplifier serves for amplifying the internal sawtooth voltage or an external deflection voltage before this is applied to the horizontal deflection plates. This circuit also comprises the "X-SHIFT" control and the "X-MAGN" control.

Cathode-ray tube

Controls INTENS and FOCUS serve for controlling the voltage on the various electrodes of the cathode-ray tube.
The high tensions for the cathode-ray tube are generated with the aid of a converter which also delivers the other supply voltages.
The Wehnelt cylinders are connected to sockets for external Z-modulation.


V / div.
1MΩ
30pF
Y_A
Attenuator
FET
Source
Followers
Preamplifier
Emitter
Follower
AC
O
DC
x1
x10
Drift
Feedback
Amplifier
DC Bal.
Trigger
Preamplifier
Trigger
Y_A
Ext.
Y_B
Trigger
Amplifier
Norm
TV Frame
Trigger
Pulse
Shaper
Time
Multi
+
-
Level
Aut.
Sync.
Separator
Trig
Aut.
Stab.
V / div.
1MΩ
30pF
Y_B
Attenuator
FET
Source
Followers
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x1
x10
Drift
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Amplifier
DC Bal
Trigger
Preamplifier

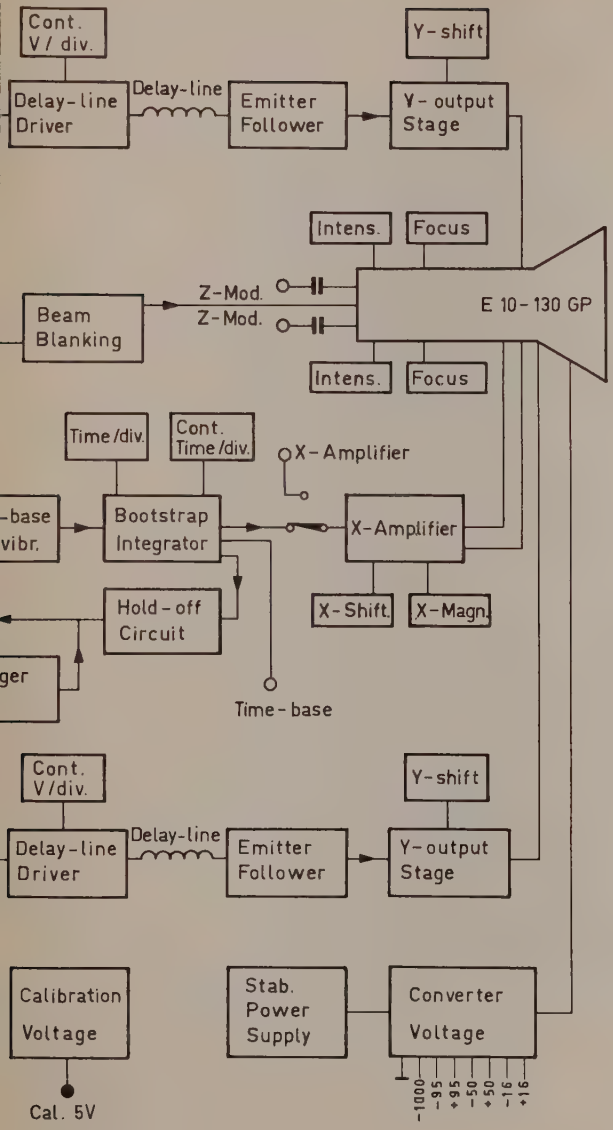


Fig. 3. Block diagram

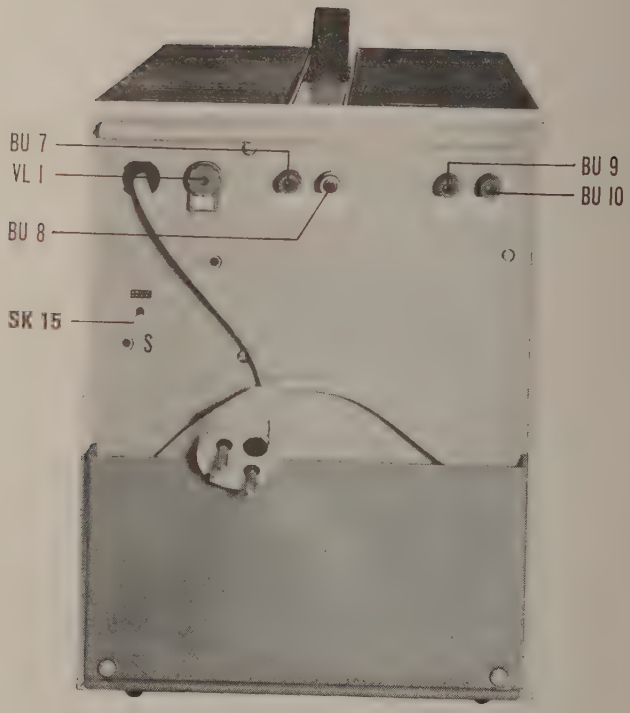


Fig. 4. Rear view

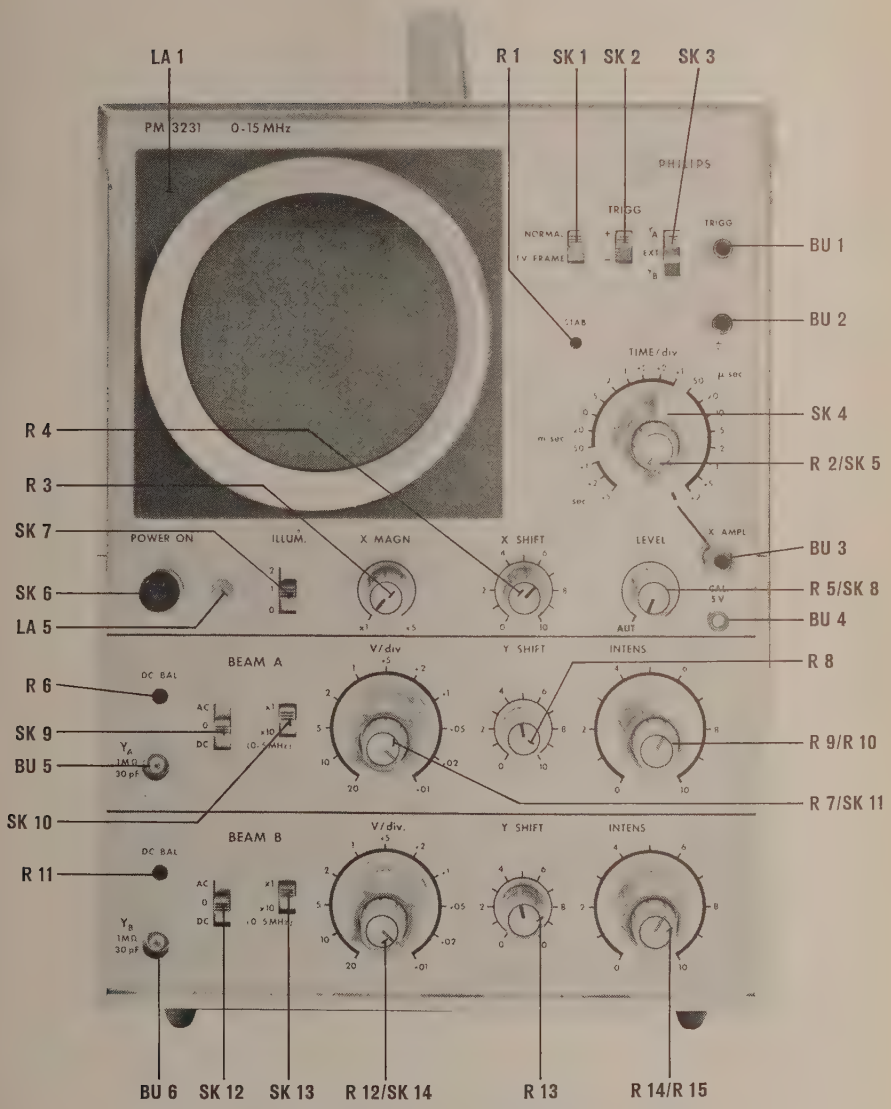


Fig. 5. Controls

DIRECTIONS FOR USE

V *Installation*

The instrument should be installed so that natural air cooling is not impeded.
The instrument can be used in the horizontal position or can be tilted back by means of the tilting bracket.

A. ADJUSTMENT TO THE LOCAL MAINS VOLTAGE

On delivery, the instrument is adjusted to a mains voltage of 187 V... 253 V (220 V nominal). When the mains voltage is 94 V... 127 V (110 V nominal), the voltage adapter at the rear of the instrument should be changed over. This is effected as follows:
- Slightly loosen screw "S" (Fig. 4).
- Push screw "S" upwards until the indication "110 V" is visible through the opening above the screw.
- Tighten screw "S" again.

B. FUSE (VL1, Fig. 4)

In the holder at the rear panel of the instrument a 1 A (delayed-action) fuse has been fitted. When the instrument is connected to a mains voltage of 94 V... 127 V, a 2 A (delayed-action) fuse should be employed.

C. EARTHING

The instrument should be earthed in accordance with local safety regulations. This can be effected:
- via earth socket "⏚" at the front or rear of the instrument;
- via the mains lead (the instrument has a 3-core mains cable).

Double earthing should be avoided as this will give rise to hum.

D. SWITCHING-ON

The instrument is switched on with switch POWER ON (SK6, Fig. 5). Pilot lamp LA5 (Fig. 5) will then light up.

E. CHECKING THE CATHODE-RAY TUBE

- Make a time-base line visible on the screen.
- Check that this line is horizontal. If necessary, correct according to chapter XII-B.

VI Operation

A. CONTROLS, SOCKETS AND THEIR FUNCTIONS (see Figs. 4, 5)

Note: The indications of the controls and sockets for channel B are given in brackets.

SK1	NORMAL/TV FRAME	Two-position selector: NORMAL: for normal triggering TV FRAME: for triggering on the frame pulses of TV signals.
SK2	TRIGG +/—	Selection between triggering on positive-going or negative-going edge of trigger signal.
SK3	Y_A-EXT-Y_B	Selection between trigger signal from channel A, an external signal or the signal from channel B.
BU1	TRIGG	Input for external trigger voltage.
BU2	⏚	Earth socket.
R1	STAB	Adjustment of trigger stability.
SK4	TIME/div	Step control of time coefficients.
R2/SK5	TIME/div - CAL	Continuous control of the time coefficients (in position CAL the time coefficients are calibrated.
BU3	X AMPL	Input of the X-amplifier. When switch TIME/div is turned fully clockwise, this input may be used for horizontal deflection by means of an external voltage.
SK6	POWER ON	Mains switch.
LA5		Mains voltage indication lamp.
SK7	ILLUM	Step control of graticule illumination.
R3	X MAGN	Continuous horizontal expansion up to 5 times.
R4	X SHIFT	Horizontal shift control.
R5/SK8	LEVEL - AUT	Adjustment of trigger level (in position AUT a stationary trace is obtained automatically).

BU4	CAL 5 V	Rectangular calibration voltage with a frequency of approx. 2.5 kHz.
R6 (R11)	DC BAL	Adjustment of d.c. balance of the Y-amplifier for channel A (B).
SK9 (SK12)	AC-0-DC	Selector for channel A (B): AC: Connection between input and Y-amplifier via an isolating capacitor. O : Connection between input and Y-amplifier interrupted. Amplifier input connected to earth. DC: Direct connection between input and Y-amplifier.
SK10 (SK13)	x1-x10	Selector for channel A (B): x1 : Y-deflection coefficients as indicated on text plate for beam A (B). x10: Y-deflection coefficients 10 times smaller than indicated on text plate for beam A (B). The bandwidth is then limited to 5 MHz.
SK11 (SK14)	V/div	Step control of the Y-deflection coefficients of beam A (B).
R7 (R12)	V/div - CAL	Continuous control of Y-deflection coefficients of beam A (B). (In position CAL the deflection coefficients are calibrated).
R8 (R13)	Y SHIFT	Vertical shift control of beam A (B).
R9 (R14)	INTENS	Intensity control of beam A (B).
R10 (R15)	FOCUS	Focusing control of beam A (B).
BU5	Y_A-1 MΩ-30 pF	Input of Y amplifier for channel A.
BU6	Y_B-1 MΩ-30 pF	Input of Y amplifier for channel B.
BU7	TIME BASE	Output on which the internal sawtooth voltage is available.
BU8	⏚	Earth socket.
BU9	Z-MOD A	Input for brightness modulation of beam A.
BU10	Z-MOD B	Input for brightness modulation of beam B.
SK15	110 V - 220 V	Mains voltage adapter.
LA1-4		Graticule illumination (only one of the four lamps is indicated in the figure).

B. MAKING THE TRACES VISIBLE

1. Preliminary settings

a. Adjusting the time base stability control

- Set continuous controls INTENS, FOCUS, Y SHIFT and X SHIFT to the centre position.
- Set switches "AC-0-DC" to position "0".
- Set switches "x1-x10" to position "x1".
- Set switch "X-MAGN" to position "x1".
- Set switch "TIME/div" to position "0.5 ms/div".
- Set control „LEVEL" to position "AUT".

Both time base lines should now be visible in the centre of the screen. If this is not the case, then:

- Set controls "INTENS" to position "x10".
- Turn control "LEVEL" out of position "AUT".
- Turn control "STAB" until both time base lines appear on the screen.
- After this set control "STAB" so that just no time base lines are visible (not too critical).
- Set control "LEVEL" to position "AUT". Both lines should now be visible.
- Set controls "INTENS" to the desired position.

b. Adjusting the D.C. balance

- Make both time base lines visible on the screen.
- Set control "Y SHIFT" of channel A to the centre position.
- Set switch "AC-0-DC" of channel A to position "0".
- Set switch "x1-x10" of channel A to position "x10".
- Set switch "V/div" of channel A to position ".01 V/div" and turn the appropriate continuous control to and fro between the minimum and maximum position. Simultaneously adjust control R6 (Fig. 5) until turning the continuous control no longer causes the time base line to shift.
- Repeat this for channel B.

2. Input circuit

The signal to be displayed should be applied to socket "Y_A", "Y_B" or to both sockets.

When the signal contains a large d.c. component, switch "AC-0-DC"

should be set to position "AC" to prevent that the signal falls outside the control range of control "Y SHIFT".
In order to facilitate a rapid determination of the zero volt d.c. level, the input switch has been provided with a position "0". In this position the amplifier input is disconnected from the input socket and connected to earth.

C. INTERNAL TRIGGERING (automatic)

- Apply the signal to be displayed as described in A.2.
- Set switch "Y_A-EXT-Y_B" to position "Y_A".
- Set switch "TRIGG + –" to the desired polarity.
- Set control "LEVEL" to position "AUT".
- Adjust the trace height with switch "V/div" and the appertaining continuous control of channel A. (The deflection coefficient is only calibrated when the continuous control is in position "CAL".)
- Adjust the sweep time with the aid of switch "TIME/div" and the appertaining continuous control. (The sweep time is only calibrated when the continuous control is in position "CAL".)
- If desired, the trace can be expanded in the horizontal direction with control "X MAGN".

Note: The same applies to channel B.

D. EXTERNAL TRIGGERING

- Apply an external trigger voltage to socket "TRIGG" and set switch "Y_A-EXT-Y_B" to position "EXT".
- Further proceed as for internal triggering.

E. TRIGGERING WITH VARIABLE TRIGGER LEVEL

- Set all controls as described for B and C.
- Set control "LEVEL" so that the time base starts at the desired level of the input signal.

F. TRIGGERING ON VIDEO SIGNALS

- Set switch "NORMAL-TV FRAME" to position "TV FRAME".
- Turn control "LEVEL" out of position "AUT".
- Further proceed as for internal triggering.
- Set switch "TRIGG + –" position "–" for a positive video signal and to position "+" for a negative video signal.

G. HORIZONTAL DEFLECTION WITH AN EXTERNAL VOLTAGE

- Set switch "TIME/div" to the extreme right position.
- Apply an external voltage to socket "X AMPL". The time base generator is now automatically switched off and blocked.
- The horizontal amplitude can be varied with knob "X MAGN".

H. BRIGHTNESS MODULATION

The voltages required for brightness modulation should be applied to sockets "Z-MOD" at the rear of the instrument.

VII *Applications*

The PM 3231 can be used for carrying out qualitative and quantitative analyses of signals as a function of time or as a function of another signal.
With the aid of some technical concepts and measuring principles, in this chapter an insight will be given into the possibilities of this instrument.

Y-DEFLECTION

Switch "AC-0-DC"

In position "DC" the input is coupled direct to the Y amplifier. Because no coupling capacitors are used, the complete bandwidth of the instrument is available. This means that input signals can be applied to the deflection plates without distortion. However, direct voltages at the input will be displayed on the screen as trace shifts. This may give rise to difficulties when signals are to be displayed which are superimposed on large direct voltages. For displaying the a.c. signal a high degree of attenuation would be necessary, so that the a.c. signal would also be attenuated. To prevent this, position "AC" has been provided.
In this position a blocking capacitor is connected between the input and the Y amplifier, so that only the a.c. component is applied to the amplifier.
However, as a result of this not only the direct voltages but also the lower frequencies (up to approx. 10 Hz) of the a.c. signal will be suppressed or attenuated. When displaying rectangular voltages of low frequency this will give rise to some degree of droop.
In position "0" of switch "AC-0-DC" the connection between the input and the Y amplifier is interrupted and the amplifier input is connected to earth. In this position the d.c. balance of the amplifier can be adjusted. Adjustment of the d.c. balance is effected as described in point VII. A.1.b.

Measuring probes

For the proper evaluation of the measuring result, it is necessary to take into account the influence of the input impedance of the oscilloscope on the circuit under test.

This impedance, which forms a load for the signal source, may in some cases affect the voltage to be measured.

At higher frequencies the input impedance is generally determined by the input capacitance. Moreover, in the case of measurements to tuned circuits, it should be taken into account that the input capacitance may cause de-tuning.

The load capacitance can be strongly reduced by using a 1 : 10 attenuator probe. Both the ohmic and the capacitive load are then reduced by approx. a factor 10.

The use of an attenuator probe has the additional advantage that the lowest frequency in the case of a.c. coupling is decreased by approximately a factor 10.

Besides, the deflection coefficients of the Y amplifier become 10 times as high, so that it is possible to display a signal with a very high amplitude. The maximum permissible voltage on the measuring probe (1000 V_{p-p}; maximum d.c. component 500 V) should, however, not be exceeded.

Voltage measurements

The measuring accuracy of $\pm$ 3 % applies to the flat part of the frequency response curve. To guarantee proper squarewave response, the amplitude-frequency characteristic of a good quality oscilloscope amplifier should start declining at approximately $^1/_3$ of the band width. This should be taken into account when determining the accuracy of the measurement.

Triggering

When a periodical signal is to be displayed, it is necessary that the X deflection always starts at a definite point of the wave form. This is in order to obtain a stationary picture.

For this, the time base is started by the trigger unit, which is controlled by a signal derived from a Y input signal or from an external source.

Automatic triggering

Automatic triggering is only possible in position NORMAL of switch NORMAL/TV FRAME. The automatic triggering mode is used in most cases because of the simple operation.

With this method triggering takes place at the average value of the trigger signal preset in the instrument.

By means of switch TRIGG +/– the trigger moment can be selected on the positive-going or negative-going edge of the trigger signal. When the trigger signal is too small or if there is no signal, the time base generator automatically changes over to the free-running condition, so that always a time base line is displayed.

Trigger level

In the case of complex signals containing a number of different voltage waveforms, the time base should always start at the same waveform in order to obtain a stationary trace. This is possible if one of the waveforms has a deviating amplitude. With control "LEVEL" the trigger level can then be adjusted so that only the larger waveform can pass this level. For displaying a leading edge it is also advisable to use the LEVEL control.
The trigger level can then be adjusted so that the time base is already started at the beginning of this leading edge.

External triggering

External triggering is applied e.g. for signals having a strongly varying amplitude, if a signal having a fixed amplitude and equal frequency is available.
This prevents the necessity to readjust the level control at each variation of the input signal.

Triggering on TV signals

To simplify triggering on TV signals, a synchronisation separator is switched on in position "TV FRAME" of switch "NORMAL/TV FRAME". This separator sorts the frame synchronising pulses out of the TV signal, after which they are used for starting the time base generator. As is known, the synchronising signals have a polarity, which is opposed to that of the video signal. If triggering on a positive video signal is required, switch "TRIGG + –" should be in position "–" and for a negative video signal in position "+".

Delay line

The input signal can also be used for triggering the time base generator. For this, the signal is applied to the trigger unit, which converts it into trigger pulses. However, the trigger unit requires some time for starting the X deflection. During this time the first part of the input signal,

which has already arrived at the deflection plates, may already have passed completely or partially. This implies that a steep leading edge will not be visible on the screen.

To prevent this, each Y amplifier has been equipped with a delay line. The trigger signal is taken off between the input and the delay line. As the delay time of the line is longer than the time required for the trigger unit to start the X deflection, the time base will start before the leading edge of the input signal has reached the deflection plates. As a result the leading edge will also be displayed.

During triggering it is recommended to use the level control, as the time base can then be started at any desired point of the leading edge. In this way the advantages of the delay line can be used completely.

Hints for measuring rise times

- The rise time is defined as the time required by the positive-going edge of a signal to rise from 10 % of the peak value to 90% of the peak value.
- When the rise time of the oscilloscope lies in the same order of magnitude as that of the object under test, the actual rise time should be calculated in accordance with the following equation.

$$Tw = \sqrt{Tm^2 - To^2}$$

in which: Tw = actual rise time
Tm = measured rise time
To = rise time of the oscilloscope (23 and 70 ns respectively)

External X-deflection

When switch TIME/div is in the fully clockwise position, the time base generator is switched off and X-deflection can take place by applying an external signal to socket "X AMPL".

Due to the presence of the delay lines the instrument can only be used to a limited extent as a X-Y oscilloscope due to the occurring phase shifts.

Brightness modulation

To display additional information in the oscillogram, brightness modulation is possible by means of an external voltage. This can be achieved by applying the external signal to sockets "Z MOD" at the rear of the instrument.

In this way it is possible to carry out very accurate time measurements in the oscillogram, when the brightness is modulated by means of time markers. The measurements can then be effected directly with the aid of the markers in the trace.

Photographing screen traces

For photographing screen traces e.g. with the aid of the Philips photographic equipment PM 9300 consisting of a Rolleicord camera, a Polaroid-Land casette and various adapters for different screen diameters, the exposure table given below can be used as a guide.

Rollfilm — *Graticule illumination: position 2 of ILLUM*

Film speed		*Relative speed*	*Shutter speed in seconds*							
ASA	DIN		1	1/2	1/4	1/8	1/15	1/30	1/60	1/125
12	12°	1	f=8	f=5.6	f=3.5					
25	15°	2	f=11	f=8	f=5.6	f=3.5				
50	18°	4	f=16	f=11	f=8	f=5.6	f=3.5			
100	21°	8	f=22	f=16	f=11	f=8	f=5.6	f=3.5		
200	24°	16		f=22	f=16	f=11	f=8	f=5.6	f=3.5	
400	27°	32			f=22	f=16	f=11	f=8	f=5.6	f=3.5
800	30°	64				f=22	f=16	f=11	f=8	f=5.6
1600	33°	128					f=22	f=16	f=11	f=8
3200	36°	256						f=22	f=16	f=11
6400	39°	512							f=22	f=16

The following points should then be taken into account:

– The table is based on the use of normal roll films.
Experience has proved that, when photographing screen traces, the correct camera setting for Polaroid films corresponds to the setting for a relative film speed of a factor 4 lower.

– The table is based on a graticule illumination corresponding to position 2 of switch ILLUM.
If position 1 of this switch is used, a camera setting should be selected which corresponds to a relative sensitivity of a factor 4 lower.

When photographing screen traces, the following points should always be taken into account:

1. If the measuring graticule is to be photographed along with the trace, the focussing should take place at a point between the trace and the engraved graticule lines (graticule with its engraved side against the cathode-ray tube).
Preferably select an aperture setting of $\geqslant 8$, so that sufficient depth of field is obtained.
After adjusting the trace to the desired brightness with the knob INTENS, adapt the graticule illumination with the knob ILLUM.
The double-exposure technique can be successfully employed, at which first the trace is photographed only and then the measuring graticule only:

   a. if an aperture setting of $\geqslant 8$ cannot be used;

   b. if difficulties arise with adaptation of the light intensity of screen trace and measuring graticule, e.g. when photographing non-recurrent phenomena.

2. Select such a shutter speed that the trace is displayed 3 to 4 times during the exposure time.
This will result in a photograph of uniform brightness.

3. Always remove the contrast filter.

4. Before every exposure, always ensure that there is no incidental external light which may cause reflections on the screen.

SERVICE DATA

VIII *Circuit description*

A. VERTICAL AMPLIFIERS (see Figs. 30 and 31)

The oscilloscope has two identical vertical amplifiers. For clarity only the amplifier for channel A is described.
The corresponding elements for the other channel are given in brackets.
The vertical amplifiers consist of the following sections:

1. Input attenuator (see Figs. 27 and 28)

The deflection coefficient of the amplifier can be increased by including a high-ohmic attenuator in the input circuit. This attenuator consists of 5 sections which provide an attenuation of:

10x	R26-R27 (R226-R227)
100x	R28-R29 (R228-R229)
1000x	R31-R32 (R232-R231)
2x	R33-R34 (R233-R234)
5x	R36-R37 (R236-R237)

With switch V/div of channel A (B) the attenuator sections can be combined so that 11 deflection coefficients can be selected.
With trimmers C26, 31, 36, 42, 43, 46 and 48 (C226, 231, 236, 242, 243, 246 and 248) frequency compensation of the sections is achieved. Trimmers C28, 33 and 38 (C228, 233 and 238) are adjusted so that the input capacitance is the same in all attenuator positions.
With switch AC-0-DC of channel A (B) input socket YA (YB) can be connected to the attenuator either direct or via an isolating capacitor. In position 0 of this switch the input of the Y amplifier is connected to earth and the connection with input socket YA (YB) is interrupted. In this position the zero level of the amplifier can be checked.

2. Pre-amplifier

The high input impedance of the pre-amplifier is obtained by means of field effect transistors TS51′ - TS51″ (TS251′ - TS251″), which are connected as source followers.
The pre-amplifier has been made drift-free by using the control circuit described in point 3.
The direct voltage on the gate of TS51″ (TS251″), which is adjustable with R6 (R11) DC BAL, serves to equalise the emitter voltage of TS73 (TS273) to the input voltage of the amplifier, when no input signal is present.
In that case there will be no direct voltage across continuous gain control R7 (R12), thus preventing the time base line from moving across the screen when R7 (R12) is turned.
The field effect transistor TS51′ (TS251′) is protected against excessively high negative input voltages by diodes GR51-GR52 (GR251-GR252), which become conductive at input voltages larger thans –1.4 V.
The capacitance of these diodes is eliminated by feeding back the signal from the emitter of TS52 (TS252) to the anode of GR51 (GR251), so that there will flow no signal current through this diode.
TS51′ (TS251′) is protected against excessively high positive input voltages by means of resistor R39 (R239), which limits the gate current.
The field effect transistors are followed by emitter followers in order to match the output impedance of the input stage to the input impedance of the pre-amplifier stage.
The pre-amplifier stage is formed by a push-pull amplifier with current and voltage feedback, which includes transistors TS53, TS54, TS71 and TS72 (TS253, TS254, TS271 and TS272). The current feedback obtained by means of the resistors in the emitter circuit of TS53 and TS71 (TS253 and TS271) ensures a high input impedance.

The voltage feedback via resistors R61 and R132 (R261 and R332) ensures that the circuit has a low output impedance.
The circuit has a large bandwidth as the capacitive interaction from the output to the input is practically eliminated.
The gain is very constant, as it is mainly determined by passive elements, viz. feedback resistors R61 and R132 (R261 and R332) and the resistors between TS53 and TS71 (TS253 and TS271).
In position x1 of switch SK10 (SK13) the gain is adjusted with potentiometer R101 (R301) and in position x10 with R104 (R304).
TS66 (TS266) ensures that there is a constant current in the amplifier

circuit. The output voltage of the pre-amplifier is taken off asymmetrically and applied to the control stage for the delay cable and the control circuit via emitter follower TS73 (TS273). The trigger signal is taken from the same emitter follower and applied to the trigger pulse shaper via amplifier stage TS75 (TS275).

3. Drift feedback (see Fig. 6)

The pre-amplifier described in point 2 is a difference amplifier. The input signal Ui is applied to input I (TS51′, TS251′) and the control voltage Ur is applied to input II.

All drift voltages are referred to input I, and it is assumed that they originate from a voltage source Ud.

Assume that the amplifier has a gain of –A times. The output voltage Uo is reduced by a factor A in the 1/A voltage divider. In the circuit diagram this voltage divider consists of resistors R138 - R139 (R338-R339) together with resistor R136 (R336) in parallel with R138 (R338) in position x10 of switch SK10 (SK13).

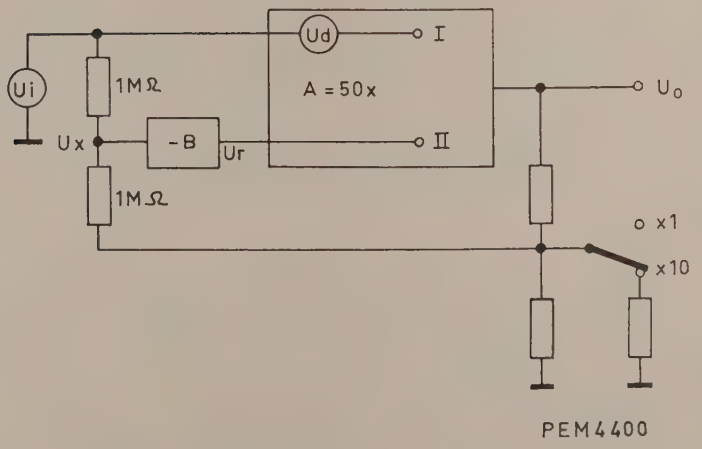


Fig. 6. Simplified diagram of the control circuit

The output signal of this voltage divider is applied to one side of the ½ voltage divider R41-R107 (R241-R307) and voltage Ui to the other side.

The input voltage Ux of control amplifier TS67′-TS67″ (TS267′-TS267″) will consequently be ½ (Ui + Uo/A). After amplification the control voltage Ur = —½ B (Ui + Uo/A).

The voltage applied to input I of the difference amplifier will, therefore, be: Ui + Ud, whereas —½ B (Ui + Uo/A) will be applied to input II.

The difference is: (Ui + Ud) — (—½ B. (Ui + Uo/A))

This difference is amplified —A times, so that:

$Uo = -A\,[(Ui + Ud) - (-\frac{1}{2}\,B\,(Ui + Uo/A)]$

or:

$$Uo = -A\left(Ui + \frac{Ud}{1 + \frac{1}{2}B}\right)$$

As the amplification of the control voltages is 60 times, the effect of the drift is reduced approx. 30 times which is amply sufficient for locking the zero line.

4. Control stage for the delay line

This stage consists of an asymmetrically driven amplifier TS58′-TS58″ (TS258′-TS258″). The base of transistor TS58′ (TS258′) is connected to earth because the base of TS58″ (TS258″) is kept at 0 V by the control circuit in the absence of a signal.

The amplification of this stage and, consequently, the vertical deflection coefficient can be continuously adjusted with potentiometer R7 (R12).

The input of the delay line is terminated by resistors R73 (R273) and R153 (R353) and its output by R76 (R276).

Via emitter followers TS59-TS76 (TS259-TS276) the signal is applied to the output stage.

5. Output stage

The output stage is driven symmetrically. The gain can be adjusted with potentiometer R82 (R282) in the emitter circuit of TS60-TS77 (TS260-TS277). The RC networks in this emitter circuit serve for correction of the squarewave response.

By means of potentiometer R8 (R13) the d.c. level at the input of the output transistors can be varied, so that the trace can be shifted across the screen in the vertical direction.

B. TRIGGER PULSE SHAPER (Fig. 34)

This shaper consists of the following sections:

- an amplifier stage TS502-TS503, whose input is a field effect transistor TS501 in source follower arrangement;
- a Schmitt trigger TS506-TS507;
- a synchronisation separator TS504.

The trigger signal can be obtained, at option, via a coupling capacitor from the Y amplifiers or direct from an external source.

1. Amplifier stage

In order to obtain a high input impedance for the trigger pulse shaper, an input source-follower has been used. This ensures that the trigger signal source is neither loaded or influenced.
The input is protected against excessively high negative input voltages by diode GR501, whereas gate current limitation occurs at excessively high positive voltages.
The amplifier stage is an emitter-coupled push-pull amplifier. The trigger signal is applied to the base of TS502. As a result, voltages of equal amplitude and opposite phase are obtained at the collectors of TS502 and TS503. By selecting one of these voltages with switch SK2 (+/—) it is possible to trigger on the positive-going or the negative-going edge of the signal.
With potentiometer R5 (LEVEL) continuous adjustment of the direct voltage on the base of TS503 is possible in the closed position of SK8 (non-automatic).
Dependent on this setting, each time a different part of the trigger signal is amplified, (as the amplifier is overdriven). The trigger level is consequently determined by the position of R5.

2. Schmitt trigger

The amplified trigger signal changes over Schmitt trigger TS506-TS507. In the case of a repetitive trigger signal a squarewave voltage with constant amplitude will arise at the collector of TS507. This voltage is differentiated into small positive and negative pulses by C608 and R657.
The positive pulses are short-circuited by diode GR603. The negative pulses are applied to the time base generator.

3. Synchronisation separator

In position TV FRAME of switch SK1, synchronisation separator TS504 is switched on. This facility permits of triggering on the frame synchronisation pulses of a TV signal.

The video signal is applied to synchronisation separator TS504, which has such a setting that peak detection takes place by the base emitter diode, so that only the peaks of the synchronising pulses lie within the operating range. By means of integrator R526-C504 the line and frame synchronisation pulses are separated.

The integrated frame synchronisation pulses then trigger Schmitt trigger TS506-TS507.

C. TIME BASE GENERATOR (Fig. 34)

The time base generator consists of a bootstrap integrator, which is driven by Schmitt trigger TS612-TS611; see simplified diagram in Fig. 7.

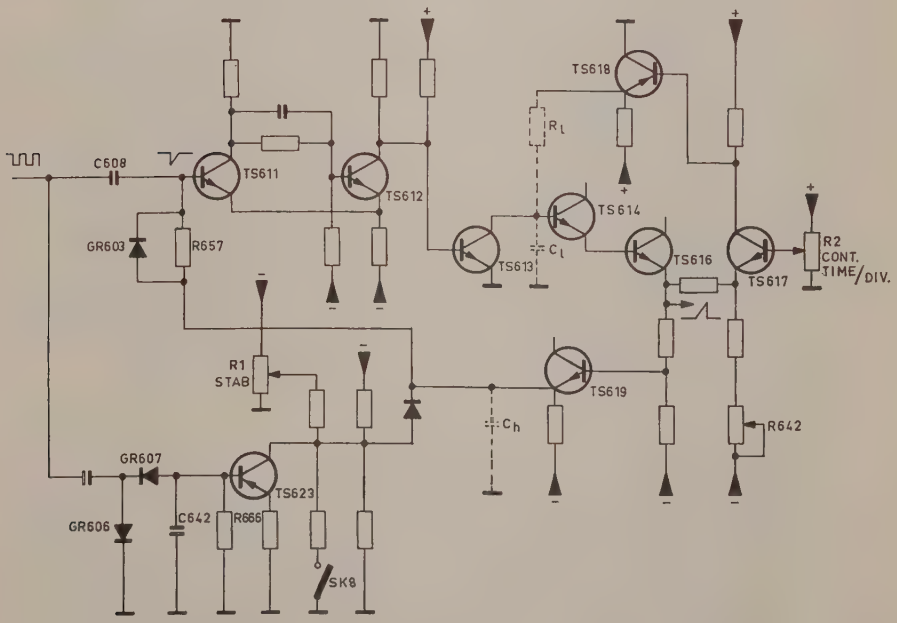


Fig. 7. Simplified diagram of the time base generator

For the description of the working it is assumed that the Schmitt trigger is in the following state: – TS611 non-conducting
– TS612 conducting

Switching transistor TS613 is now cut off. The time base capacitor C_L is now charged with a constant current determined by R_L so that a linearly increasing voltage arises across this capacitor.
The constant charging current is obtained by feedback in the bootstrap integrator, so that the voltage across the charging resistor is maintained constant. This feedback takes place via transistors TS617 and TS618.
R2 as well as R642 enable adjustment of the direct current through TS617, so that it is possible to vary the constant voltage across R_L and, consequently, the time coefficient. R2 is the continuous control, R642 serves for internal calibration.
The linearly increasing voltage across C_L is fed back to Schmitt trigger TS611-TS612 via TS614, TS616 and TS619, so that TS611 will be turned on and TS612 will be turned off.

Switching transistor TS613 is now turned on and the time base capacitor then discharges via this transistor. The voltage at the input of the Schmitt trigger will, consequently, decrease to a certain value. When the next trigger pulse appears, the Schmitt trigger will change over again and the time base capacitor is charged again.

The stability of the time base generator can be adjusted with potentiometer R1 (STAB). This determines the value of the direct voltage on the base of TS611. This direct voltage is selected so that the pulse occurring at the end of the flyback on the base of TS611, cannot change over the Schmitt trigger.
The feedback circuit also comprises the hold-off capacitors, which ensure that the time base capacitors can fully discharge after the forward scan. At the following pulse the sawtooth voltage always starts at the same level. By means of switch SK4, 20 different time coefficients can be selected by switching in various capacitors and charging resistors. With R2 continuous control of the charging voltage and, consequently, of the time coefficient is possible. The time coefficient is calibrated when R2 is turned fully clockwise.
The sawtooth voltage is taken from the emitter of TS617 and applied to the horizontal amplifier (via SK4-I-F) and to output terminal BU7 (TIME BASE).

Automatic trigger circuit

In position AUT of potentiometer LEVEL (SK8 open) the voltage on the base of TS611, in the absence of a trigger signal, is determined by the position of potentiometer R1, as TS623 receives no negative base voltage.

This voltage level causes the time base generator to free run. If there is a trigger signal, the base of TS623 will become negative due to the working of GR606, GR607, C642 and R666. As a result of this TS623 is turned on, so that the base of TS611 will become less negative. On account of this the time base generator is no longer free running and it will only change over due to the trigger pulses applied via C608.

D. BEAM DEFLECTION (Fig. 34)

To ensure that the electron beam is not visible during the flyback, such a voltage is applied to the third grid of the cathode-ray tube (points 7 and 9) that blanking occurs.

The voltage required for this is supplied by Schmitt trigger TS611-TS612 of the time base generator and applied to the cathode-ray tube via circuit TS603-TS604-TS606.

The flyback is suppressed at the moment that TS611 is cut off. The collector of this transistor then has a negative voltage, which is applied to the base of emitter follower TS603. As a result, transistor TS604 is turned off and its collector voltage will rise.

This rise is passed on to the third grid of the cathode-ray tube (deflection plates) via emitter follower TS606.

Due to this there will be a voltage difference of approx. 45 V between g2 and the deflection plates, so that the electron beam is intercepted. To improve the slope, diode GR600 and emitter follower TS606 have been provided.

During the change-over of Schmitt trigger TS611-TS612 the output voltage of TS606 will become approx. 0 V, so that the trace is displayed again.

E. HORIZONTAL AMPLIFIER (Fig. 34)

The horizontal amplifier is an asymmetrically driven push-pull amplifier with current and voltage feedback (TS702, TS703, TS704, TS708, TS709, TS711). The asymmetrical drive is obtained via emitter follower TS701.

The negative feedback and, consequently, the deflection sensitivity of the output stage can be adjusted with potentiometer R718. With potentiometer R3 (X MAGN) the sensitivity can be varied by a factor 5. Horizontal shift takes place by varying the d.c. level on the base of emitter follower TS506 with potentiometer R4 (X SHIFT).
In position X AMPL of switch SK4 the connection between the time base generator and the horizontal amplifier is interrupted. Now it is possible to apply an external signal to the horizontal amplifier via socket BU3. In order to prevent crosstalk of the time base voltage on the horizontal amplifier, the time base generator is connected to earth in this position of SK4. Moreover, the hold-off circuit is connected to the -16 V via R655, so that time base multivibrator TS611-TS612 is always in position TS611 conducting /TS612 non-conducting, thus ensuring unblanking.

F. CATHODE-RAY TUBE CIRCUIT (Fig. 37)

Individual brightness control of the two systems is possible with potentiometers R9 and R14. The control range is determined by the setting of potentiometers R403, R402, R414 and R416. The brightness voltage is stabilised by neon stabiliser B401.
Focusing takes place with potentiometers R10 and R15, whereas R407 and R419 permit of correction of the astigmatism of the electrostatic lens.
Barrel and pin-cushion distortion can be corrected with R408 and the relative shift of the traces in the horizontal direction due to the differences in the deflection systems can be eliminated with R409.
Brightness modulation is possible via sockets BU9 and BU10.

G. CALIBRATION VOLTAGE GENERATOR

The calibration voltage generator consists of a free-running multivibrator TS901-TS902 whose output voltage is kept constant by zener diode GR901.

H. SUPPLY CIRCUIT

The alternating voltage across winding S3 of supply transformer T801 is full-wave rectified and, subsequently, electronically stabilised. This is effected by comparing a voltage which is proportional to the output

voltage, with a reference voltage (GR803) via a difference amplifier (TS804-TS806). The difference, if any, is amplified (TS803) and applied to the series regulators (TS801-TS802), which compensate for the difference.

The stabilised voltage is applied to a converter circuit, which delivers all the supply voltages in the instrument.

These voltages can be adjusted by means of potentiometer R808. The ripple voltage can be reduced to a minimum by means of potentiometer R803.

IX *Gaining access to the components*

Caution

In this instrument very high voltages are generated so that due care should be taken when carrying out work on the interior of the instrument.

A. REMOVING THE SIDE PANELS

On both sides of the instrument a panel has been fitted which is secured by means of two quick-fasteners.
Loosen these fasteners and remove the panels from the frame.

B. REMOVING THE KNOBS (Fig. 8)

Single knobs

- Remove cap A.
- Loosen screw B.
- Pull the knob off the spindle.

Double knobs

- Remove cap A.
- Remove screw B.
- Remove the inner knob.
- Loosen nut C.
- Pull the outer knob off the spindle.

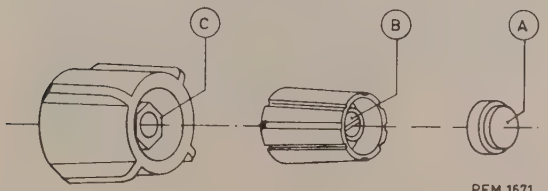


Fig. 8. Removing the knobs

C. REMOVING THE PROTECTIVE CAP AND THE GRATICULE (Fig. 9)

- Hold the protective cap as indicated in Fig. 9 and pull the lower section upwards.
- The protective cap, the graticule and the contrast enhancing filter can now be removed.

D. GAINING ACCESS TO THE DELAY LINE (Fig. 24)

- Place the instrument on one side.
- Slide the small bottom plate out of the instrument.
- Unsolder the 8 connections of the delay line.
- Loosen the two fixing screws BS (see Fig. 10).
- The delay line can now be slide out of the instrument.

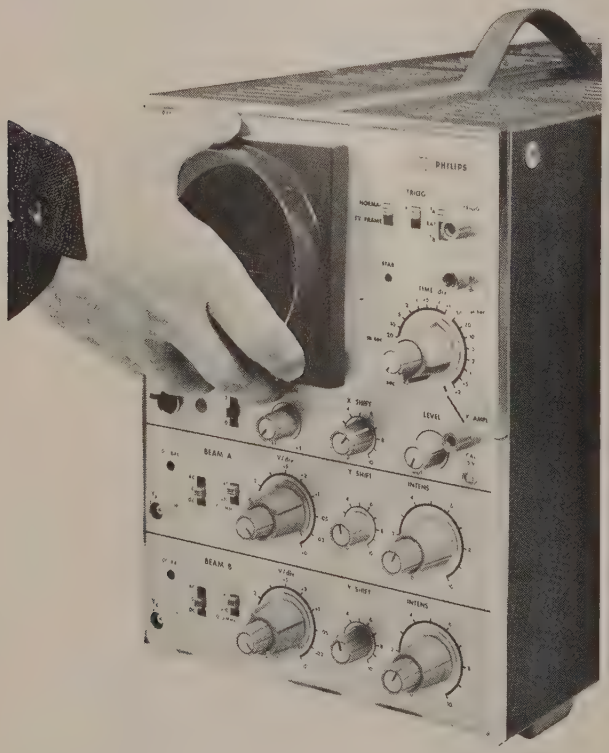


Fig. 9. Removing the protective cap and the graticule

X *Adjusting elements and their functions*

(see Figs. 10 and 11)

The order given below is arbitrary. For the complete adjusting procedure please refer to chapter XI.

Adjustment	*Adjusting element*	*Measuring instrument*	*PHILIPS type*	*Chapter XI point*
Vertical amplifiers				
d.c. balance	R113 (R313) R114 (R314) R116 (R316)			D - 1
Sensitivity	R82 (R282) R101 (R301) R104 (R304)	LF generator	PM 5120	D - 2
Squarewave response of attenuators	C26 (C226) C28 (C228) C31 (C231) C33 (C233) C36 (C236) C38 (C238) C42 (C242) C43 (C243) C46 (C246) C48 (C248)	Squarewave generator	PM 5710	D - 4
Squarewave response of amplifiers	C50 (C250) C55 (C255) C54 (C254) C56 (C256) C59 (C259) C60 (C260) R160 (R360) R162 (R362) R163 (R363)	Squarewave generator	PM 5710	D - 4

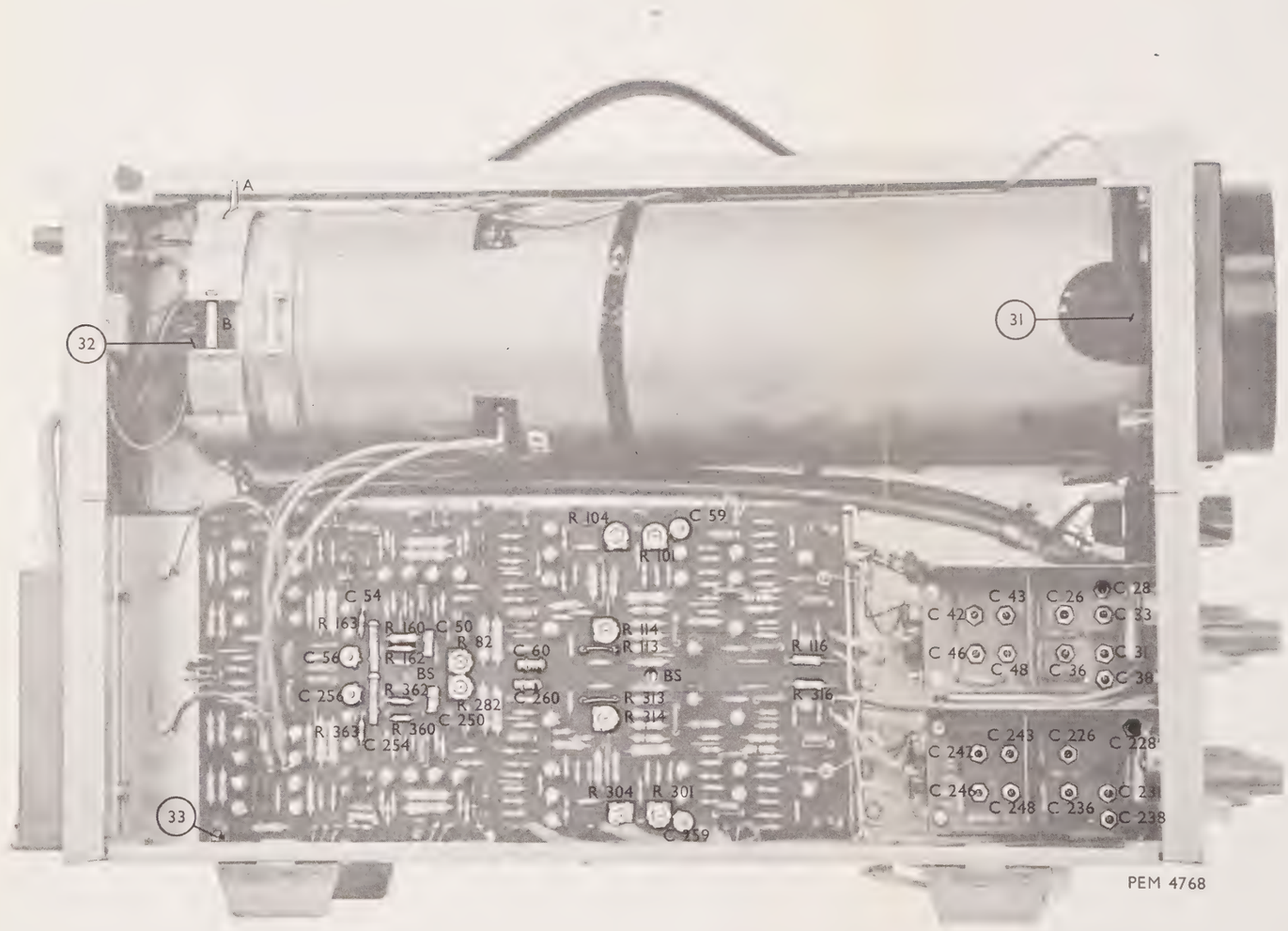


Fig. 10. Left-hand side view with adjusting elements

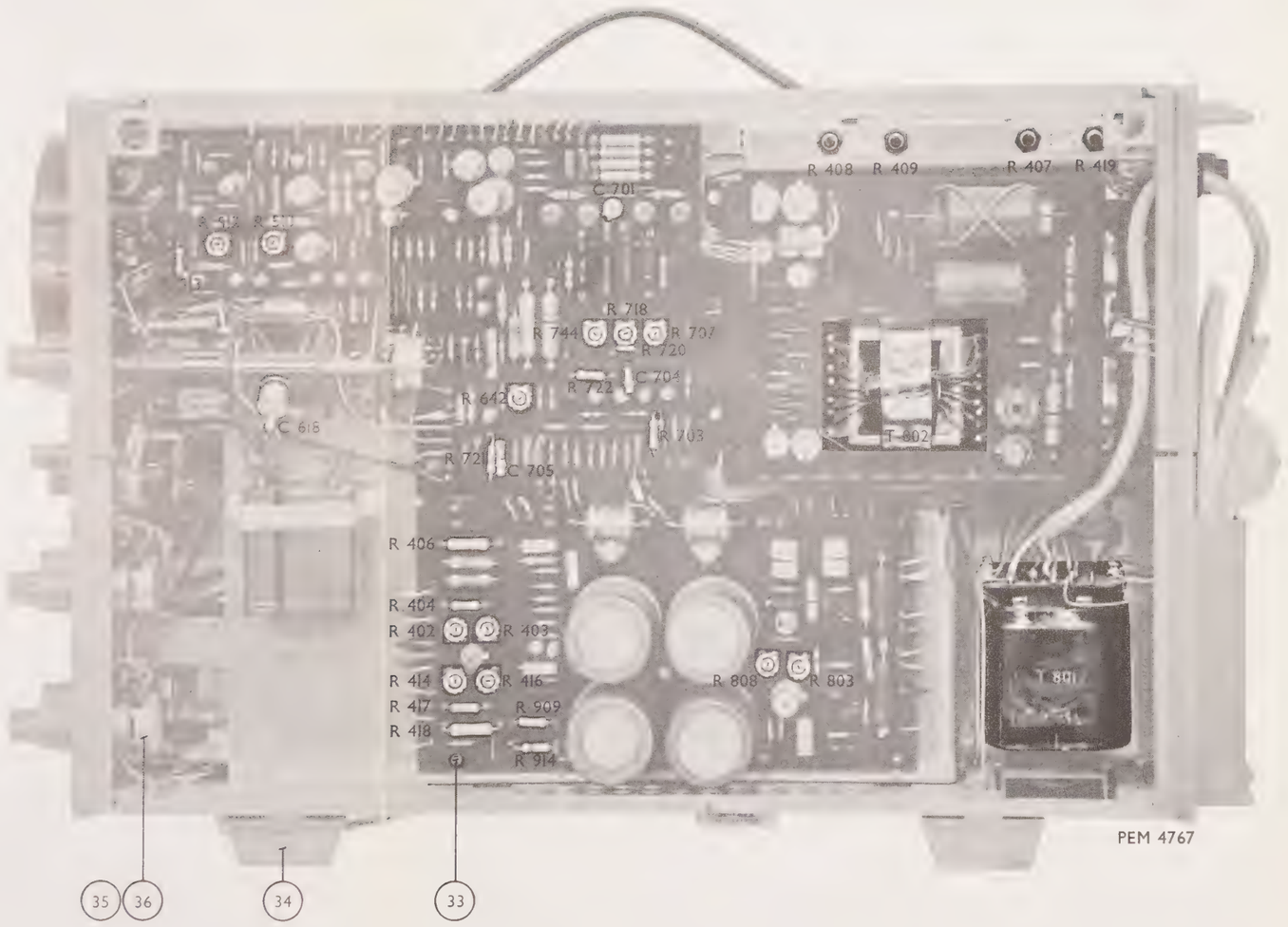


Fig. 11. Right-hand side view with adjusting elements

Adjustment	*Adjusting element*	*Measuring instrument*	*PHILIPS type*	*Chapter XI point*
Calibration voltage				
	R909, R914			
Horizontal amplifier				
Sensitivity	R703, R718 R712, R722	LF generator	PM 5120	E - 2
Squarewave response	C704, R720 C705	Squarewave generator	PM 5710	E - 3
Trigger pulse shaper				
Trigger level	R510, R512 R513	LF generator HF generator	PM 5120 PM 5321	F - 2
Time base generator				
Time coefficients	R642, C618	LF generator	PM 5120	F - 3
Power supply				
—16G Amplitude	R808	Variable transformer DC voltmeter	E401AB/010 PM 2401	B
Ripple	R803	Oscilloscope	PM 3230	B
Cathode-ray tube				
Intensity	R402 (R414) R403 (R416) R404 (R417)			C - 2
Focus and astigmatism	R406 (R418) R407 (R419)			C - 1
Barrel and pin-cushion distortion	R408, R409 R707, R744 C701	LF generator	PM 5120	C - 1

XI *Checking and adjusting*

A. GENERAL

The tolerances specified below are factory tolerances which only apply to a completely readjusted instrument. Therefore, they may deviate from the data mentioned in chapter II.

All adjusting elements, their functions and their location are stated in the table in chapter X.

The adjustment should be effected at a temperature between 20° C and 25° C.

B. POWER SUPPLY

Check that the mains voltage adapter is adjusted to 220 V and connect the instrument to a 220 V supply (50 Hz).

The current consumed from the mains should not exceed 500 mA (to be measured with moving iron meter).

–16 G

– Measure the voltage at junction R800-R812.
This should be –16 V. If this is not the case, it can be accurately adjusted to –16 V with potentiometer R808.

Attention: After changing the setting of R808 all subsequent checks must be effected.

– Adjust the ripple on the –16 V direct voltage to minimum with potentiometer R803.

– By means of a variable transformer vary the alternating voltage to which the instrument is connected between 187 and 253 V.
The variations of the –16 V voltage should not be more than 160 mV.
The max. ripple voltage is 100 mV_{p-p}.

+95 D

– Measure the voltage on junction R843-R844.
This should be +95 V, + or — 10 %.

+16 J

– Measure the voltage on junction R858-R860.
This voltage should lie between +16.3 and 18.3 V.

– Vary the voltage to which the instrument is connected between 187 and 253 V by means of a variable transformer.
The +16 J direct voltage should not vary.
The hum voltage plus converter interference voltage should not exceed 20 mV.

C. CATHODE-RAY TUBE CIRCUIT

1. Picture distortion

- Set TIME/div to position 1 msec/div.
- Set AC-0-DC A (B) to position DC.
- Set YA-EXT-YB to position YA.
- Display a time base line for channel A.
- Check whether a sharply defined time base line is written at normal brightness. If necessary, focus with FOCUS A and R407 (astigmatism).
- Check whether the time line is horizontal. If necessary, the C.R.T. can be positioned correctly with lever A (Fig. 10), after loosening locking screw B.
- Apply signals of the same phase and a frequency of 20 kHz to sockets YA and YB. Adjust for a picture height of 8 divisions and adjust the two pictures symmetrically with respect to the screen centre by means of the SHIFT potentiometers.
- Adjust for a triggered picture with LEVEL.
- Check that the pictures are sharply defined at normal brightness. If necessary, focus with FOCUS A and B and R407 or R419 (astigmatism).
- Adjust the barrel and pin-cushion distortion to minimum with potentiometer R408 (readjust focusing and astigmatism). If necessary, determine average setting for channels A and B.
- Subsequently adjust potentiometer R409 so that the envelopes of the two traces are parallel at the top and the bottom. If necessary, use an average setting for top and bottom.
- Repeat the above check.
- Reduce the picture height for both channels to 6 divisions.
- Select such a time coefficient that 6 periods are displayed.
- Make the pictures coincide as much as possible with the aid of SHIFT controls and the continuous attenuator.
- Check whether the four innermost periods of the two pictures coincide. On the X axis both pictures should cover each other completely; a small deviation may occur in the peaks. Correction is possible with potentiometers R707 and R744.
- Set TIME/div to position .2 μsec/div.
- Set X-MAGN to position x5.
- Increase the frequency of the input signal to 5 MHz.

– Check whether the pictures coincide. If necessary, adjust with C701. If the pictures do not coincide in the screen centre, potentiometer R409 should also be adjusted. However, in that case the settings of R408, R707 and R744 should be checked in succession.

2. Intensity

Beam A

– Set LEVEL to position AUT.
– Set TIME/div to the extreme right position.
– Turn INTENS of channel B fully anti-clockwise.
– Connect socket CAL to input socket YA.
– Adjust for symmetry of the picture with respect to the screen centre by means of the SHIFT controls.
– Adjust for a sharply defined picture with FOCUS of channel A.
– If necessary, repeat the focus adjustment of point C1 and, if required, select a smaller value for R404.
– Turn INTENS of channel A anti-clockwise till the picture just disappears.
– Now measure the dark current by including a μA meter in the post-acceleration lead.
– Turn INTENS of channel A fully clockwise and adjust R403 so that the current variation indicated by the μA meter is 12 μA.
– Set INTENS of channel A to scale gradation 4.
– Adjust R402 so that the picture just disappears. If necessary, select a smaller value for R404.
– Repeat both adjustments.

Beam B

As under beam A; however, read INTENS of channel B for INTENS of channel A, INTENS of channel A for INTENS of channel B, R416 for R403 and R414 for R402 and R417 for R404.

D. Y-AMPLIFIERS

Both amplifiers are identical, so that the adjusting procedure is the same for both amplifiers. The controls and sockets pertaining to channel B are indicated in brackets after those for channel A.

1. D.C. balance

- Set AC-0-DC of channel A (B) to position 0.
- Set x1-x10 of channel A (B) to position x10.
- Set V/div of channel A (B) to position 10 mV/div.
- Set LEVEL to position AUT.
- Set Y SHIFT of channel A (B) to the centre position.
- Adjust DC BAL of channel A (B) so that the picture line is not shifted when potentiometer V/div is turned.
- Set AC-0-DC of channel A (B) to position AC.
- Adjust R114 (R314) so that the time base line does not jump when AC-0-DC of channel A (B) is switched from position AC to position 0.
- Set x1-x10 of channel A (B) to position x1. The picture line should not move more than 1 division.
- Apply a squarewave voltage with a frequency of 10 Hz to YA (YB).
- Set AC-0-DC of channel A (B) to position DC.
- Adjust for a stationary trace with LEVEL.
- Check whether the top of the squarewave voltage is straight. If necessary, correct with potentiometer R101 (R301).
- Set x1-x10 of channel A (B) to position x10.
- Set V/div of channel A (B) to position 100 mV/div.
- Check whether the top of the squarewave voltage displayed is straight. If necessary, correct with R104 (R304).

2. Deflection coefficient

- Set AC-0-DC of channel A (B) to position DC.
- Set x1-x10 of channel A (B) to position x1.
- Set V/div to position 10 mV/div.
- Set potentiometer V/div of channel A (B) to position CAL.
- Apply an 80 mV_{p-p} voltage with a frequency of 2 kHz to socket YA (YB).
- Check that the picture height is 8 divisions. If necessary, adjust the picture height to exactly 8 divisions with R82 (R282).
- Set x1-x10 of channel A (B) to position x10.
- Set V/div of channel A (B) to position 100 mV/div.

- Check that the picture height is 8 divisions, + or — 1 %.
- Display a picture with a height of 8 divisions.
- Turn potentiometer V/div of channel A (B) fully anticlockwise from the CAL position. The picture height should now be between 3 and 1.3 divisions.

3. Noise

- Set x1-x10 of channel A (B) to position x10.
- Set V/div of channel A (B) to position 10 mV/div.
- With open-circuited input the height of the trace caused by noise should not exceed 0.2 divisions. The interference signal of the H.T. converter should not cause a trace height of more than 0.1 division. For this measurement the cabinet panels should be mounted.

4. Square wave response

- Set AC-0-DC of channel A (B) to position DC.
- Set x1-x10 of channel A (B) to position x1.
- Set V/div of channel A (B) to position 10 mV/div.
- Set potentiometer V/div of channel A (B) to position CAL.
- Apply a squarewave voltage of 60 mV_{p-p}, frequency 500 kHz, rise time approx. 10 ns to socket YA (YB).
- Adjust for a stationary trace with LEVEL.
- Adjust trimmers C55 (C255), C56 (C256) and C59 (C259) so that just no overshoot occurs and that the rise time of the squarewave voltage displayed is minimum.
- Reduce the frequency of the input voltage to 100 kHz.
- Check that no droop occurs. If necessary, select another value for the components of RC filter R162 (R362)-C54 (C254) and R160 (R360)-C50 (C250). After this, the check at 500 kHz should be repeated.
- Apply a squarewave voltage with a frequency of 2 kHz to YA (YB).
- At a trace height of 4 divisions, + or — 2.5 %, adjust the relevant trimmers (see table) so that just no overshoot occurs.

Position of V/div of channel A (B)	*Trimmer*
20 mV	C42 (C242)
50 mV	C46 (C246)
100 mV	C26 (C226)
200 mV	C43 (C243)
500 mV	C48 (C248)
1 V	C31 (C231)
10 V	C36 (C236)

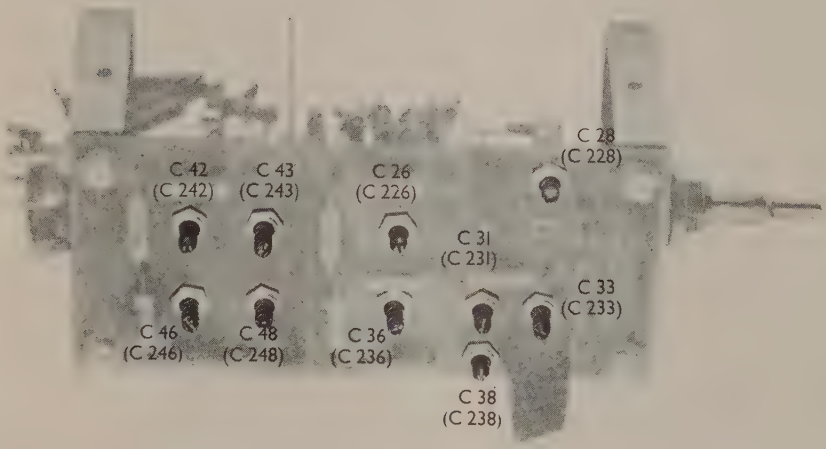


Fig. 12. Attenuator unit

- Set x1-x10 of channel A (B) to position x10.
- At a trace height of 8 divisions check the squarewave response in positions 1 mV, 2 mV and 5 mV/div.
- The max. permissible overshoot is then 3 %.
- Connect a 1 : 10 attenuator probe to socket YA (YB).
- Set x1-x10 of channel A (B) to position x1.
- Set V/div of channel A (B) to position 10 mV/div.

- Apply a squarewave voltage of 400 mV_{p-p}, frequency 2 kHz, to the measuring probe.
- Check the squarewave response via the measuring probe; permissible overshoot 2 % (Fig. 13).
  If necessary, readjust the trimmer in the measuring probe (see chapter XII).
- Check the attenuation of the measuring probe. This should be 10x, + or — 2.5 %.
- Set x1-x10 of channel A (B) to position x10.
- Check the squarewave response via the measuring probe in positions 100 mV, 1 V and 10 V of V/div of channel A (B) at a trace height of 4 divisions. If necessary, correct this with trimmers C28 (C228), C33 (C233) and C38 (C238).
- Set x1-x10 of channel A (B) to position x1.
- Check the squarewave response at a trace height of 4 divisions in positions 20 mV and 50 mV of V/div of channel A (B).

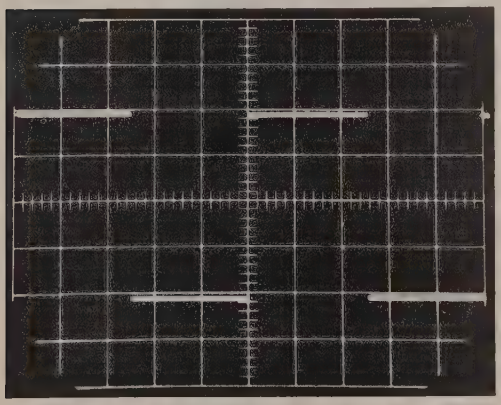


Fig. 13. Squarewave response

5. Bandwidth
   - Set V/div of channel A (B) to position 10 mV/div.
   - Successively set x1-x10 of channel A (B) to positions x1 and x10.
   - Check that the bandwidth meets the following requirements at a trace height of 8 divisions.

Position x1	*Position x10*
2 kHz = 8 div	2 kHz = 8 div
15 MHz ⩾ 5.6 div	5 MHz ⩾ 5.6 div

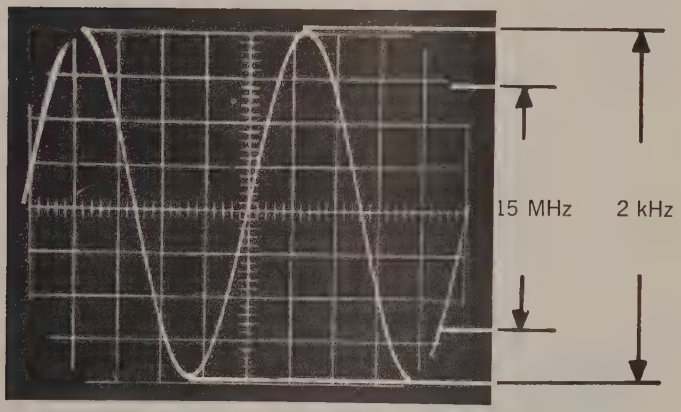


Fig. 14. Band width

- If necessary, correct the squarewave responses.
- Check that in position AC of AC-0-DC of channel A (B) a voltage applied to socket YA (YB) is blocked by capacitor C51 (C251).

6. Deflection and shift

- Set AC-0-DC of channel A (B) to position DC.
- Set x1-x10 of channel A (B) to position x1.
- Set V/div of channel A (B) to position 100 mV/div.
- Set potentiometer V/div of channel A (B) to position CAL.
- Apply a sinewave voltage to socket YA (YB) with a frequency of 1 MHz and such an amplitude that the picture height is 2.4 divisions.
- Set V/div of channel A (B) to position 10 mV/div.
- Check that the peaks of the signal can be displayed undistorted within the measuring graticule by means of Y SHIFT of channel A (B).

E. X-AMPLIFIER

1. D.C. balance

- Set TIME/div to the extreme right position.
- Check that the voltage on socket X-AMPL is 0 V, + or — 100 mV.
- Adjust X SHIFT so that the spots do not shift when X MAGN is turned. The spots should not be more than 1.5 division to the left or to the right of the vertical centre line.

2. Sensitivity

- Set TIME/div to the extreme right position.
- Set X MAGN to position x1.
- Apply a squarewave voltage of 8 V_{p-p} frequency 2 kHz to socket X-AMPL.
- Position the trace symmetrically around the screen centre with X SHIFT.
- Check that the picture width is 8 divisions. If necessary, adjust R718 so that the width is exactly 8 divisions.
- Reduce the input voltage to 1.6 V_{p-p}.
- Set X MAGN to position x5.
  The trace width should now be 8 divisions + or — 5 %. If required, select another value for R721. After this, readjust R718.

3. Squarewave response

- Set X MAGN to position x1.
- Apply a squarewave voltage of 8 V_{p-p}, frequency 100 kHz to socket X-AMPL.
- Apply an external time base voltage to socket YA.
- Check that the squarewave response is optimum.
  If required, select another value for R720 and C704.
- Set X MAGN to position x5.
- Reduce the input voltage to 1.6 V_{p-p}.
- Check that the squarewave response is optimum.
  If required, select another value for C705. In the latter case the check in position x1 of X MAGN should be repeated.

4. Bandwidth

- Set X MAGN to position x5.
- Check the bandwidth at a trace width of 8 divisions.

This should meet the following requirements.
2 kHz = 8 divisions
2 MHz ⩾ 5.6 divisions
– If necessary, repeat point 3.

F. TIME BASE GENERATOR

1. Stability

– Set AC-0-DC of channel A to position 0.
– Set X MAGN to position x1.
– Set Y_A-EXT-Y_B to position Y_A.
– Set Y SHIFT and LEVEL to the centre position.
– Set TIME/div to position 0.5 msec.
– Set potentiometer TIME/div to position CAL.
– Adjust STAB so that just no time base line is displayed.
– Set LEVEL to position AUT.

Now a time base line should be displayed.

2. Triggering

a. Internal

– Set NORMAL/TV FRAME to position NORMAL.
– Set YA-EXT-YB to position YA.
– Set potentiometers TIME/div and V/div of channel A to position CAL.
– Set switch TIME/div of channel A to position 0.5 msec.
– Set LEVEL to position AUT.
– Apply a sinewave voltage to socket YA, with a frequency of 2 kHz and such an amplitude that the trace height is 4 divisions.
– Check that the starting point of the signal lies at the zero line of the sinewave when changing over TRIGG +/–.
Correction is possible with R512 and, if necessary, R510.
– Repeat this check at a trace height at which correct adjustment just remains possible.
– Increase the amplitude of the input signal until a trace height of 8 divisions is obtained.
– Check that the trigger level can be varied over 7 divisions with LEVEL.
– Turn LEVEL fully anti-clockwise (not in position AUT), and fully clockwise. In the two extreme positions the time base generator should be stopped.

The following checks should be carried out both for channel A and for channel B.

- Set LEVEL to position AUT.
- Set YA-EXT-YB to position YA-(YB).
- Set potentiometers TIME/div and V/div of channel A (B) to position CAL.
- Apply sinewave voltages with frequencies of 10 Hz and 5 MHz to socket YA (YB).
- Check that a stationary trace is obtained at a trace height of 0.8 divisions and with switch TRIGG +/— both in position + and —
- Increase the frequency of the input signal to 15 MHz.
- Check that a stationary trace is obtained at a trace height of 1.6 divisions.
- Set LEVEL out of position AUT.
- Check that a stationary trace can be obtained with LEVEL at a trace heigt of 0.4 divisions and frequencies of 10 Hz and 5 MHz.
- Repeat this check at a trace height of 1.6 divisions and a frequency of 15 MHz.
- Check that no double trace occurs when the time coefficient is varied with potentiometer TIME/div.

b. External

- Set YA-EXT-YB to position EXT.
- Set LEVEL to position AUT.
- Apply a sinewave voltage of 0.8 V_{p-p}, frequency 10 Hz, to socket TRIGG.
- Also apply this voltage to socket YA.
- A stationary trace should now be obtained.
- Check this both in position + and — of the switch TRIGG +/—.
- Repeat this check at frequencies of 5 MHz and 15 MHz.
- Set LEVEL out of position AUT.
- Reduce the voltage on socket TRIGG to 0.4 V_{p-p} (at 15 MHz to 0.8 V_{p-p}).
- Check that at frequencies of 10 Hz, 5 MHz and 15 MHz a stationary trace can be obtained by means of control LEVEL.

c. TV frame

- Set YA-EXT-YB to position YA.
- Set NORMAL/TV FRAME to position TV FRAME.

- Set switch TRIGG +/— to position —.
- Check if it is possible with LEVEL to obtain a picture triggered on the frame pulse, at a trace height of 0.8 divisions (video including synchronising signal).

3. Time coefficients

- Set NORMAL/TV FRAME to position NORMAL.
- Set switch TRIGG +/— to position +.
- Set YA-EXT-YB to position YA.
- Set TIME/div to position 1 msec/div.
- Set potentiometer TIME/div to position CAL.
- Set X MAGN to position x1.
- Apply a pulse voltage with a pulse duration of 1 msec to socket YA.
- Check that over the central 8 divisions 8 complete periods are displayed. Correction is possible with R642.
- Check the time coefficient in positions 0.2 msec/div and 50 μsec/div over the central 8 divisions.
- Check the time coefficient in position 0.2 μsec/div.
  If required, accurate adjustment is possible with trimmer C618.
- Check the time coefficients and the length of the time base line in all positions of TIME/div.
  The time coefficients should be equal to the values given on the text plate within 2 %. The length of the time base line should be at least 10 divisions in every position.
- Set TIME/div to position 2 msec/div.
- Check the control range of potentiometer TIME/div.
  This should be at least 1 : 2.5.

4. Shift

- Set TIME/div to position 0.2 sec/div.
- Set AC-0-DC of channel A to position AC.
- Set potentiometer TIME/div to position CAL.
- Set X MAGN to position x5.
- Set LEVEL to position AUT.
- Check that the ends of the time base line can be displayed within the screen with control X SHIFT.

5. Beam deflection

- Set LEVEL to position AUT.
- Set TIME/div to positions 0.2, 0.5 and 2 msec/div. successively.

– Check that max. 2 divisions of the flyback of the sawtooth voltage are visible and that the brightness of the time base line is constant over its whole length.

6. **Z-modulation**

– Apply a negative pulse voltage of 15 V_{p-p} with a frequency of 2 kHz to socket Z-MOD A (B).
– Trigger the instrument with this voltage.
– Check the brightness modulation of the trace at normal brightness.

7. **Sawtooth voltage on socket TIME BASE**

Check that this voltage has a value of approx. 8 V_{p-p} at no load.

XII *Replacing parts*

A. GENERAL

After replacing a component it may be necessary to completely readjust the relevant circuit.
For this reference is made to chapter "CHECKING AND ADJUSTING" and the footnotes of the electrical parts list.
During the replacement of components the instrument should be switched off.

B. REPLACING THE CATHODE-RAY TUBE

Attention:

When replacing the cathode-ray tube it should be taken into account that all connection pins of this tube are very vulnerable.

1. Remove the H.T. connection.
2. Remove the protective cap, the graticule and the contrast-enhancing material.
3. Loosen locking screw B (see Fig. 10).
4. Remove the tube holder and detach all tube connections.
5. Push the tube out of the oscilloscope in forward direction.
6. Mount the new tube in the oscilloscope.
   Place the tube in the correct position with the aid of lever "A" (Fig. 10).
7. Tighten locking screw B.
8. Refit the tube holder and the tube connections.
9. Refit the protective cap, the graticule and the contrast-enhancing filter.
10. Readjust the instrument according to chapter "CHECKING AND ADJUSTING".

XIII *Information for assistance in fault finding*

A. TRANSFORMER DATA

On the circuit diagram of the supply unit (Fig. 37) tables are given with the winding data and no load voltages of supply transformer T801 and the winding data of converter transformer T802.

B. VOLTAGE LEVELS AND VOLTAGE WAVEFORMS

The d.c. levels on the electrodes of the transistors and the voltage waveforms in the time base generator and the trigger unit are indicated on the circuit diagrams (Figs. 30, 31, 32, 34).
The d.c. values have been measured with voltmeter PM 2401; the voltage waveforms have been measured with oscilloscope PM 3221. These values may slightly differ per instrument.
The measurements have been carried out under the following conditions:

- Switches AC-0-DC in position 0.
- Switches V/div in position .01 V/div.
- Potentiometers V/div in position CAL.
- Switch TIME/div in position .1 msec/div.
- Potentiometer TIME/div in position CAL.
- Potentiometer LEVEL in position AUT.
- Potentiometer X MAGN in position x1.
- Switches x1-x10 in position x10.
- Potentiometers X SHIFT and Y SHIFT in the centre position.

C. NOTES:

In case of a defect it is always possible to apply to the world wide Philips Service Organisation.
When the instrument is to be sent to a Philips Service Workshop for repair, the following points should be observed:

- Attach a label with your name and address to the instrument.
- Give a complete description of the faults found.
- Use the original packing or, if this is no longer available, carefully pack the instrument in a wooden crate or box.
- Send the instrument to the address obtained after consultation with the local Philips Organisation.

XIV *Information concerning accessories*

A. ADAPTOR PM 9051

This is an adapter to make a BNC socket suitable for the connection of two 4 mm plugs.

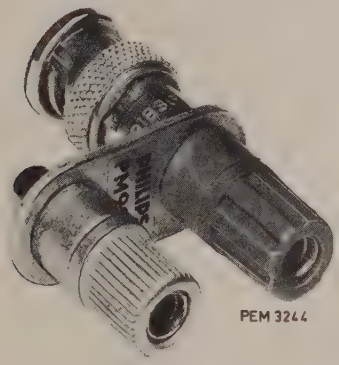


Fig. 15. Adaptor PM 9051

B. ATTENUATOR PROBE SETS PM 9326 AND PM 9327

These passive probe sets for the PM 3230 are equal but for the length of the probe cable, which is 1.15 m (3.8 ft) for the PM 9326 and 2 m (6.5 ft) for the PM 9327.

The sets consist of:

1 probe cable	Fig. 17a
1 earthing flex 15 cm (6″)	Fig. 17b
1 earthing flex 30 cm (1′)	Fig. 17c
1 measuring probe 1 : 1 (black)	Fig. 17d
1 measuring pin	Fig. 17e
1 measuring hook	Fig. 17f
1 attenuator probe 1 : 10 (grey)	Fig. 17g
1 measuring clip	Fig. 17h
1 box	Fig. 17i

The attenuator probe may cause distortion if it is not correctly adjusted (see "Checking and adjusting" chapter XD).

1. Technical data

1. Technical data

Attenuation : 1 : 10 ± 3 %
Input impedance : 10 MΩ//8pF
Max. permissible input voltage : 1,000 V_{p}

Maximum d.c. component 500V with the blocking capacitor included into the circuit.

2. Adjustment (see Fig. 18)

- Unscrew the probe locking screw "a" by turning it anti-clockwise.
- Rotate the probe body "b" to change capacitance while watching display for desired wave form, as shown in Fig. 19.
- When compensation is completed, carefully turn the locking screw clockwise, to lock it without disturbing the adjustment.

3. Dismantling the attenuator probe (see Fig. 16)

- Pull the cable i from the probe.
- Screw the measuring hook ii from the probe.
- Unscrew rotor iii from the tube.
- The resistor with bushing iv, pressure spring v and contact vi can then be removed.
  Unscrew stator vii from the tube.

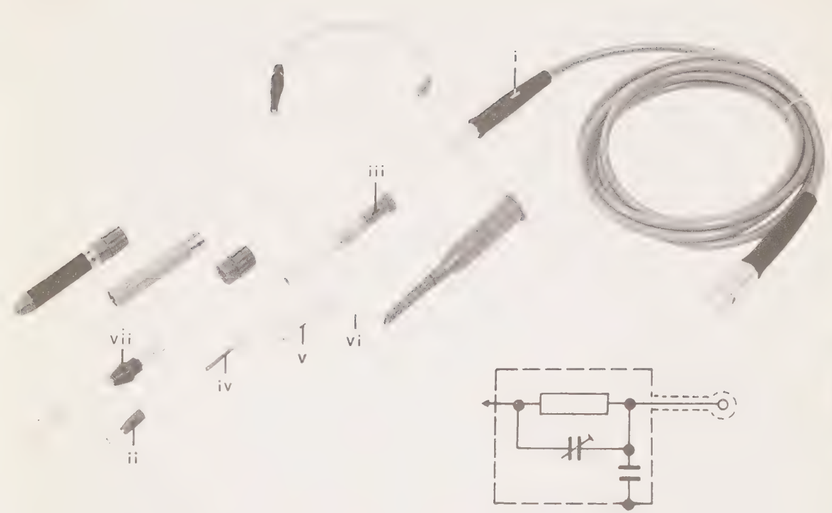


Fig. 16. Dismantling the probe

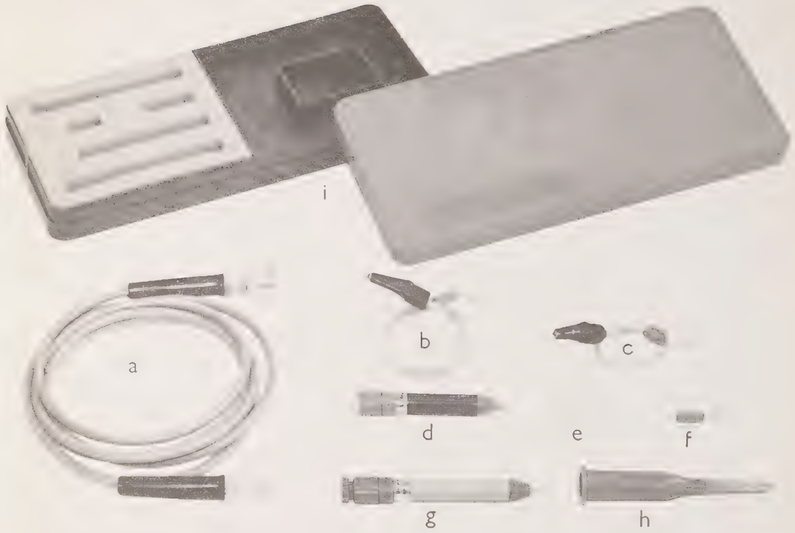


Fig. 17. Probe set

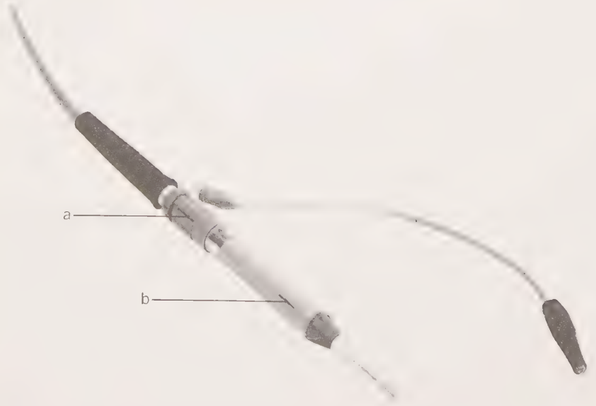


Fig. 18. Adjusting the probe

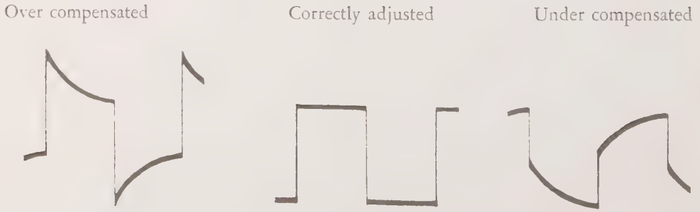


Fig. 19. Wave forms showing probe adjustment

Fig. 20. Viewing hood

Fig. 21. Carrying case

C. VIEWING HOOD PM 9370 (Fig. 20)

This is a rubber viewing hood for shielding the tube face from external light when the intensity of the light produced by the oscilloscope screen is low e.g. when observing phenomena with a low repetition frequency and a fast rise-time.

D. CARRYING CASE PM 9303 (Fig. 21)

This is a leather carrying case in which is room for a PM3230 and accessories such as two sets of measuring probes and measuring cables.

XV *Lists of parts*

A. MECHANICAL

Item	*Fig.*	*Number*	*Ordering number*	*Description*
1	22	1	4822 455 80049	Text plate
2	22	5	4822 277 20014	Slide switch SK1-SK2-SK10-SK13
3	22	4	4822 277 20009	Slide switch SK3-SK7-SK9-SK12
4	22	5	4822 290 40011	Connection terminal BU1-BU3-BU7-BU9-BU10
5	22	2	4822 290 40012	Earthing terminal BU2-BU8
6	22	3	4822 413 40112	Knob, 23 mm diam., spindle 6 mm diam.
7	22	5	4822 413 30085	Knob, 14.5 mm diam., spindle 4 mm diam.
8	22	5	4822 413 70059	Cover for knob item 7
9	22	1	4822 101 40041	Potentiometer with switch (R2 + SK5)
10	22	1	4822 273 80123	Time base switch SK4
11	22	1	4822 [illegible] 80058	Grommet for BU4
12	22	1	4822 [illegible] 10031	Contact pen for BU4
13	22	5	4822 413 30082	Knob, 14.5 mm diam., spindle 6 mm diam.
14	22	5	4822 [illegible] 70058	Cover for knob item 13
15	22	1	4822 [illegible] 40019	Potentiometer with switch (R5 + SK8)
16	22	2	4822 [illegible] 40211	Knob, 23 mm diam., spindle 6 mm diam.
17	22	2	4822 [illegible] 60073	Attenuator switch SK11-SK14
18	22	2	4822 [illegible] 10004	BNC connector BU5 - BU6
19	22	1	4822 [illegible] 10116	Lens for LA5
20	22	1	4822 [illegible] 10007	Lamp holder for LA5
21	22	1	4822 [illegible] 10042	Mains switch SK6
22	22	4	4822 [illegible] 20022	Lamp holder for LA1...LA4
23	22	1	4822 [illegible] 10012	Graticule
24	22	1	4822 [illegible] 30036	Contrast plate
25	23	1	4822 [illegible] 60011	Ornamental strip
26	23	1	4822 [illegible] 40068	Handle
27	23	1	4822 [illegible] 80004	Mains cord container
28	23	1	4822 [illegible] 60119	Grommet
29	23	1	4822 265 40012	Fuse holder
30	23	1	4822 277 20014	Slide switch SK15
31	10	1	4822 290 30044	Anode contact
32	10	1	4822 255 70099	Valve socket for B402
33	10	22	4822 693 40002	Printplate fixing clip
34	10-24	4	4822 462 70221	Foot
35	11	2	4822 532 50035	Spacer for R10-R9 and R14-R15

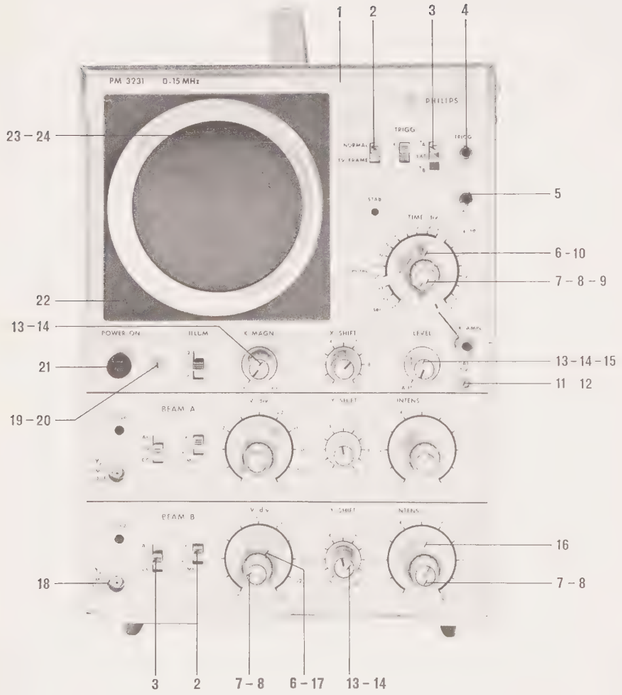


Fig. 22. Front view with indication of item numbers

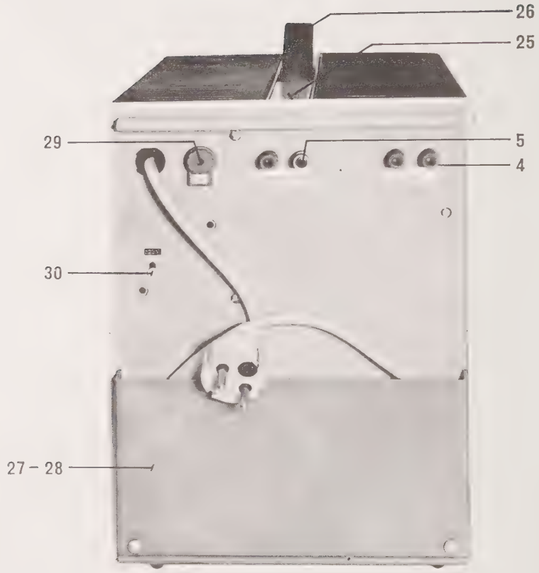


Fig. 23. Rear view with indication of item numbers

Item	*Fig.*	*Number*	*Ordering number*	*Description*
36	11	2	4822 506 40009	Plastic nut for R10-R9 and R14-R15
37	24	1	4822 320 40022	Delay cable
—	—	1fl	4822 390 10007	Switch oil
—	—	7	4822 255 40015	Transistor socket TO-5
—	—	4	4822 255 40012	Transistor socket Preh.
—	—	37	4822 255 40057	Transistor socket Lumberg

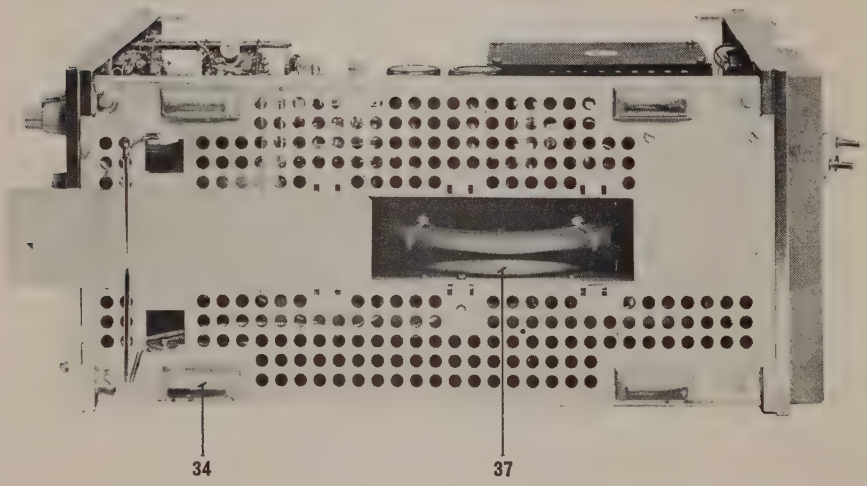


Fig. 24. Bottom view with indication of item numbers

B. ELECTRICAL — ELEKTRISCH — ELEKTRISCH — ELECTRIQUE — ELECTRICOS

This parts list does not contain multi-purpose and standard parts. These components are indicated in the circuit diagram by means of identification marks. The specification can be derived from the survey below.

Diese Ersatzteilliste enthält keine Universal- und Standard-Teile. Diese sind im jeweiligen Prinzipschaltbild mit Kennzeichnungen versehen. Die Spezifikation kann aus nachstehender Übersicht abgeleitet werden.

In deze stuklijst zijn geen universele en standaardonderdelen opgenomen. Deze componenten zijn in het principeschema met een merkteken aangegeven. De specificatie van deze merktekens is hieronder vermeld.

La présente liste ne contient pas des pièces universelles et standard. Celles-ci ont été repérées dans le schéma de principe. Leurs specifications sont indiquées ci-dessous.

Esta lista de componentes no comprende componentes universales ni standard. Estos componentes están provistos en el esquema de principio de una marca. El significado de estas marcas se indica a continuación.

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
} 0,125 W 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
} 0,25 W ≦ 1 MΩ, 5%
> 1 MΩ, 10%

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
} 0,5 W ≦ 5 MΩ, 1%
5 ≦ 10 MΩ, 2%
> 10 MΩ, 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
} 0,5 W ≦1,5MΩ, 5%
>1,5MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
} 1 W ≦ 2,2 MΩ, 5%
>2,2 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
} 2 W 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
} 0,4 – 1,8 W 0,5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
} 5,5 W ≦ 200 Ω, 10%
>200 Ω, 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
} 10 W 5%

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
} 500 V

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
} 700 V

Ceramic capacitor, "pin-up"
Keramikkondensator "Pin-up" (Perltyp)
Keramische kondensator "Pin-up" type
Condensateur céramique, type perle
Condensador cerámico, versión "colgable"
} 500 V

"Microplate" ceramic capacitor
Miniatur-Scheibenkondensator
"Microplate" keramische kondensator
Condensateur céramique "microplate"
Condensador cerámico "microplaca"
} 30 V

Mica capacitor
Glimmerkondensator
Micakondensator
Condensateur au mica
Condensador de mica
} 500 V

Polyester capacitor
Polyesterkondensator
Polyesterkondensator
Condensateur au polyester
Condensador polyester
} 400 V

Flat-foil polyester capacitor
Miniatur-Polyesterkondensator (flach)
Platte miniatuur polyesterkondensator
Condensateur au polyester, type plat
Condensador polyester, tipo de placas planas
} 250 V

Paper capacitor
Papierkondensator
Papierkondensator
Condensateur au papier
Condensador de papel
} 1000 V

Wire-wound trimmer
Drahttrimmer
Draadgewonden trimmer
Trimmer à fil
Trimmer bobinado

Tubular ceramic trimmer
Rohrtrimmer
Buisvormige keramische trimmer
Trimmer céramique tubulaire
Trimmer cerámico tubular

For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.
Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.
Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.
Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.
Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.

RESISTORS

No.	*Ordering number*	*Value*	*Watt*	*%*	*Description*
R1	4822 101 20004	22 kΩ	0.1	20	Potentiometer
R2	4822 101 40041	4.7 kΩ	¼	20	Potentiometer with switch (SK5)
R3	4822 101 20108	4.7 kΩ	¼	20	Potentiometer
R4	4822 101 20111	22 kΩ	0.1	20	Potentiometer
R5	4822 101 40019	100 kΩ	¼	20	Potentiometer with switch (SK8)
R6	4822 101 20074	2.2 kΩ	0.1	20	Potentiometer
R7	4822 101 20269	250 Ω	0.15	20	
R8	4822 101 20271	300 Ω	¼	20	
R9 R10	4822 102 10058	2x1 MΩ	¼	20	Dual potentiometer
R11	4822 101 20074	2.2 kΩ	0.1	20	Potentiometer
R12	4822 101 20269	250 Ω	0.15	20	
R13	4822 101 20271	300 Ω	¼	20	
R14 R15	4822 102 10058	2x1 MΩ	¼	20	Dual potentiometer
R26	4822 116 50197	900 kΩ	⅛	1	Carbon resistor
R27	4822 111 20115	111 kΩ	⅛	1	
R28	4822 116 50046	990 kΩ	⅛	1	
R29	4822 116 50284	10.1 kΩ	⅛	1	
R33	4822 110 30187	500 kΩ	⅛	1	
R36	4822 111 20147	800 kΩ	⅛	1	
R37	4822 116 50193	250 kΩ	⅛	1	
R82	4822 100 10037	1 kΩ	0.1	20	Potentiometer
R101	4822 100 10038	470 Ω	0.1	20	
R104	4822 100 10075	100 Ω	0.1	20	
R114	4822 100 10037	1 kΩ	0.1	20	
R226	4822 116 50197	900 kΩ	⅛	1	Carbon resistor
R227	4822 111 20115	111 kΩ	⅛	1	
R228	4822 116 50046	990 kΩ	⅛	1	
R229	4822 116 50284	10.1 kΩ	⅛	1	
R233	4822 110 30187	500 kΩ	⅛	1	
R236	4822 111 20147	800 kΩ	⅛	1	
R237	4822 116 50193	250 kΩ	⅛	1	

No.	*Ordering number*	*Value*	*Watt*	*%*	*Description*
R282	4822 100 10037	1 kΩ	0.1	20	
R301	4822 100 10038	470 Ω	0.1	20	
R304	4822 100 10075	100 Ω	0.1	20	
R314	4822 100 10037	1 kΩ	0.1	20	
R402	4822 100 10089	1 kΩ	0.1	20	
R403	4822 100 10089	1 MΩ	0.1	20	
R407	4822 101 20081	470 kΩ	0.1	20	
R408	4822 101 20081	470 kΩ	0.1	20	Potentiometer
R409	4822 101 20081	470 kΩ	0.1	20	
R414	4822 100 10089	1 MΩ	0.1	20	
R416	4822 100 10089	1 MΩ	0.1	20	
R419	4822 101 20081	470 kΩ	0.1	20	
R510	4822 100 10038	470 Ω	0.1	20	
R512	4822 100 10059	220 Ω	0.1		
R629	4822 116 50145	60 kΩ	¼	1	Carbon resistor
R632	4822 111 20144	600 kΩ	¼	1	
R642	4822 100 10038	470 Ω	0.1	20	Potentiometer
R707	4822 100 10036	4.7 kΩ	0.1	20	
R718	4822 100 10035	10 kΩ	0.1	20	Potentiometer
R744	4822 100 10036	4.7 kΩ	0.1	20	
R800	4822 115 40072	10 Ω	16	5	Carbon resistor
R803	4822 100 10037	1 kΩ	0.1	20	Potentiometer
R804	4822 113 60002	1 Ω	2	10	Carbon resistor
R806	4822 113 60002	1 Ω	2	10	
R808	4822 100 10037	1 kΩ	0.1	20	

CAPACITORS

No.	*Ordering number*	*Value*	*Volt*	*%*	*Description*
C51	4822 121 40145	100 nF	630 V		Polyester
C56	4822 125 50018	18.5 pF	50 V		Trimmer
C59	4822 125 50018	18.5 pF	50 V		
C251	4822 121 40145	100 nF	630 V		Polyester
C256	4822 125 50018	18.5 pF	50 V		Trimmer
C259	4822 125 50018	18.5 pF	50 V		

No.	Ordering number	Value	Volt	%	Description
C401	4822 121 40123	15 nF	1600 V		Polyester
C402	4822 121 40123	15 nF	1600 V		
C507	4822 124 20344	2.5 µF	16 V		Electrolytic
C602	4822 120 60106	910 pF	500 V		Mica
C603	4822 111 30192	1 µF	200 V		Box capacitor
C604		100 nF	200 V		
C606		10 nF	200 V		
C607	4822 121 10105	10 µF	200 V		
C619	4822 120 60083	120 pF	500 V	1	Mica
C631	4822 124 20344	2.5 µF	16 V		Electrolytic
C641	4822 124 20355	10 µF	16 V		
C642	4822 124 20353	10 µF	25 V		
C701	4822 125 50025	4.5 pF	50 V		Trimmer
C801	4822 124 40003	1600 µF	40 V		Electrolytic
C802	4822 124 20157	8 µF	64 V		
C803	4822 121 40194	220 nF	100 V	10	Polyester
C806	4822 124 10012	100 µF	20 V		Tantalum
C807	4822 124 10005	3.3 µF	15 V		
C808	4822 124 10005	3.3 µF	15 V		
C809	4822 124 20194	32 µF	100 V		Electrolytic
C814	4822 124 20372	32 µF	64 V		
C818	4822 124 20369	50 µF	25 V		
C819	4822 124 20379	80 µF	25 V		
C820	4822 124 20355	12.5 µF	25 V		
C821	4822 124 10014	4.7 µF	25 V		Tantalum
C823	4822 124 20379	80 µF	25 V		Electrolytic
C824	4822 124 20379	80 µF	25 V		
C826	4822 124 10014	4.7 µF	25 V		Tantalum
C829	4822 124 20372	32 µF	64 V		Electrolytic
C833	4822 124 20194	32 µF	100 V		
C834	4822 124 20194	32 µF	100 V		
C836	4822 124 20194	32 µF	100 V		
C838	4822 121 40123	15 nF	1600 V		Polyester
C839	4822 121 40123	15 nF	1600 V		
C841	4822 121 30062	10 nF	3 kV		Jensen
C842	4822 121 30088	6.8 nF	5 kV		

No.	*Ordering number*	*Value*	*Volt*	*%*	*Description*
C843	4822 121 40194	220 nF	100 V		Polyester
C844	4822 121 40194	220 nF	100 V		
C845	4822 124 20379	80 µF	25 V		Electrolytic
C851	4822 121 40194	220 nF	100 V		Polyester
C852	4822 121 40194	220 nF	100 V		
C855	4822 124 20379	80 µF	25 V		Electrolytic
C902	4822 121 40036	100 nF	100 V		Polyester

LIMIT VALUES OF CHOICE COMPONENTS

When adjusting the instrument, the values of the choice components should be selected between the following limit values.
The choice components can be recognised in the circuit diagrams by the hatching over the components and the lacking of a value indication.

RESISTORS

R113	0 Ω...	2.2 kΩ	R404	560 kΩ...	1.5 MΩ
R116	100 Ω...	5.6 kΩ	R406	1,8 MΩ...	3.9 MΩ
R130	100 Ω...	2.2 kΩ	R417	560 kΩ...	1.5 MΩ
R160	10 kΩ...	33 kΩ	R418	1.8 MΩ...	3.9 MΩ
R162	56 kΩ...	180 kΩ	R513	1.8 kΩ...	15 kΩ
R163	0 Ω...	200 Ω	R703	82 kΩ...	180 kΩ
R313	0 Ω...	2.2 kΩ	R720	10 Ω...	39 Ω
R316	100 Ω...	5.6 kΩ	R721	150 Ω...	1 kΩ
R330	100 Ω...	2.2 kΩ	R722	1 kΩ...	8.2 kΩ
R360	10 kΩ...	33 kΩ	R909	6.8 kΩ...	27 kΩ
R362	56 kΩ...	180 kΩ	R914	100 kΩ...	1 MΩ
R363	0 Ω...	200 Ω			

CAPACITORS

C50	3.3 pF...	15 pF	C254	10 pF...	330 pF
C54	10 pF...	330 pF	C260	0 pF...	82 pF
C60	0 pF...	82 pF	C704	12 pF...	47 pF
C250	3.3 pF...	15 pF	C705	56 pF...	220 pF

SEMICONDUCTORS

No.	*Type*	*Ordering number*	*Description*
GR51	BAY 38	4822 130 40256	Silicon diode
GR52	OA 202	4822 130 30239	Silicon diode
GR58	BA 148	4822 130 30256	Silicon diode
GR59	BA 148	4822 130 30256	Silicon diode
GR62	BA 148	4822 130 30256	Silicon diode
GR63	BA 148	4822 130 30256	Silicon diode
GR251	BAY 38	4822 130 40356	Silicon diode
GR252	OA 202	4822 130 30239	Silicon diode
GR258	BA 148	4822 130 30256	Silicon diode
GR259	BA 148	4822 130 30256	Silicon diode
GR262	BA 148	4822 130 30256	Silicon diode
GR263	BA 148	4822 130 30256	Silicon diode
GR501	OA 202	4822 130 30239	Silicon diode
GR600	BAY 38	4822 130 40256	Silicon diode
GR601	BZY 63	4822 130 30245	Zener diode
GR602	BAX 13	4822 130 40182	Silicon diode
GR603	AAZ 17	4822 130 30283	Germanium diode
GR606	BAX 13	4822 130 40182	Silicon diode
GR607	BAX 13	4822 130 40182	Silicon diode
GR608	BAX 13	4822 130 40182	Silicon diode
GR611	BAX 13	4822 130 40182	Silicon diode
GR701	BA 114	4822 130 30189	Silicon diode
GR702	BA 114	4822 130 30189	Silicon diode
GR703	AAZ 13	4822 130 30231	Germanium diode
GR704	AAZ 13	4822 130 30231	Germanium diode
GR705	BZY 88/C8V2	4822 130 30285	Zener diode
GR706	BA 114	4822 130 30189	Silicon diode
GR707	BA 114	4822 130 30189	Silicon diode
GR708	OA 202	4822 130 30239	Silicon diode
GR709	OA 202	4822 130 30239	Silicon diode
GR711	BZX 61/C68	4822 130 30431	Zener diode
GR712	BZX 61/C68	4822 130 30431	Zener diode
GR801	BYX 21/200	4822 130 30329	Silicon diode
GR802	BYX 21/200	4822 130 30329	Silicon diode
GR803	BZY 58	4822 130 30324	Zener diode

No.	*Type*	*Ordering number*	*Description*
GR804	OA 202	4822 130 30239	Silicon diode
GR805	BYX 21/200R	4822 130 30268	Silicon diode
GR806	OA 202	4822 130 30239	Silicon diode
GR807	OA 202	4822 130 30239	Silicon diode
GR808	OA 202	4822 130 30239	Silicon diode
GR809	BA 148	4822 130 30256	Silicon diode
GR810	BYX 21/200R	4822 130 30268	Silicon diode
GR811	BA 148	4822 130 30256	Silicon diode
GR812	BA 148	4822 130 30256	Silicon diode
GR813	BA 148	4822 130 30256	Silicon diode
GR814	OA 202	4822 130 30239	Silicon diode
GR816	OA 202	4822 130 30239	Silicon diode
GR817	OA 202	4822 130 30239	Silicon diode
GR818	OA 202	4822 130 30239	Silicon diode
GR819	BYX 10	4822 130 30195	Silicon diode
GR820	BYX 10	4822 130 30195	Silicon diode
GR821	BYX 10	4822 130 30195	Silicon diode
GR822	BYX 10	4822 130 30195	Silicon diode
GR823	BYX 10	4822 130 30195	Silicon diode
GR824	BYX 10	4822 130 30195	Silicon diode
GR825	BYX 10	4822 130 30195	Silicon diode
GR826	BYX 10	4822 130 30195	Silicon diode
GR827	BZY 63	4822 130 30245	Zener diode
GR828	BZY 63	4822 130 30245	Zener diode
GR829	BZY 63	4822 130 30245	Zener diode
GR833	BZY 63	4822 130 30245	Zener diode
GR834	BZY 63	4822 130 30245	Zener diode
GR836	BZY 63	4822 130 30245	Zener diode
GR837	BZY 63	4822 130 30245	Zener diode
GR841	BZY 63	4822 130 30245	Zener diode
GR901	BZY 60	4822 130 30196	Zener diode
TS51′	BFW 10	4822 130 40189	Field effect transistor, selected pair
TS51″	BFW 10		

No.	*Type*	*Ordering number*	*Description*
TS52	BF 115	4822 130 40308	Silicon transistor
TS53	BF 115	4822 130 40308	Silicon transistor
TS54	AF 121	4822 130 40385	Germanium transistor
TS58′	BSY 39	4822 130 40188	Selected transistor pair, silicon
TS58″	BSY 39		
TS59	BF 115	4822 130 40308	Silicon transistor
TS60	BCY 70	4822 130 40324	Silicon transistor
TS61	BF 173	4822 130 40326	Silicon transistor
TS62	BF 173	4822 130 40326	Silicon transistor
TS63	BF 173	4822 130 40326	Silicon transistor
TS64	BF 173	4822 130 40326	Silicon transistor
TS66	BF 115	4822 130 40308	Silicon transistor
TS67	BCY 87	4822 130 40423	Silicon transistor
TS69	BF 115	4822 130 40308	Silicon transistor
TS71	BF 115	4822 130 40308	Silicon transistor
TS72	AF 121	4822 130 40385	Germanium transistor
TS73	BF 115	4822 130 40308	Silicon transistor
TS75	BF 115	4822 130 40308	Silicon transistor
TS76	BF 115	4822 130 40308	Silicon transistor
TS77	BCY 70	4822 130 40324	Silicon transistor
TS78	BF 173	4822 130 40326	Silicon transistor
TS79	BF 173	4822 130 40326	Silicon transistor
TS81	BF 173	4822 130 40326	Silicon transistor
TS82	BF 173	4822 130 40326	Silicon transistor
TS251′	BFW 10	4822 130 40189	Field effect transistor, selected pair
TS251″	BFW 10		
TS252	BF 115	4822 130 40308	Silicon transistor
TS253	BF 115	4822 130 40308	Silicon transistor
TS254	AF 121	4822 130 40385	Germanium transistor
TS258′	BSY 39	4822 130 40188	Selected transistor pair
TS258″	BSY 39		
TS259	BF 115	4822 130 40308	Silicon transistor
TS260	BCY 70	4822 130 40324	Silicon transistor

No.	*Type*	*Ordering number*	*Description*
TS261	BF 173	4822 130 40326	Silicon transistor
TS262	BF 173	4822 130 40326	Silicon transistor
TS263	BF 173	4822 130 40326	Silicon transistor
TS264	BF 173	4822 130 40326	Silicon transistor
TS266	BF 115	4822 130 40308	Silicon transistor
TS267	BCY 87	4822 130 40423	Silicon transistor
TS269	BF 115	4822 130 40308	Silicon transistor
TS271	BF 115	4822 130 40308	Silicon transistor
TS272	AF 121	4822 130 40385	Germanium transistor
TS273	BF 115	4822 130 40308	Silicon transistor
TS275	BF 115	4822 130 40308	Silicon transistor
TS276	BF 115	4822 130 40308	Silicon transistor
TS277	BCY 70	4822 130 40324	Silicon transistor
TS278	BF 173	4822 130 40326	Silicon transistor
TS279	BF 173	4822 130 40326	Silicon transistor
TS281	BF 173	4822 130 40326	Silicon transistor
TS282	BF 173	4822 130 40326	Silicon transistor
TS501	BFW 10	4822 130 40443	Field effect transistor
TS502	BF 115	4822 130 40308	Silicon transistor
TS503	BF 115	4822 130 40308	Silicon transistor
TS504	BF 115	4822 130 40308	Silicon transistor
TS506	BF 115	4822 130 40308	Silicon transistor
TS507	BF 115	4822 130 40308	Silicon transistor
TS603	FW 5324	4822 130 40142	Fairchild silicon transistor
TS604	BF 115	4822 130 40308	Silicon transistor
TS606	BF 178	4822 130 40299	Silicon transistor
TS611	BF 115	4822 130 40308	Silicon transistor
TS612	BF 115	4822 130 40308	Silicon transistor
TS613	BSY 39	4822 130 40125	Silicon transistor
TS614	BC 107	4822 130 40184	Silicon transistor
TS616	BC 107	4822 130 40184	Silicon transistor
TS617	BF 115	4822 130 40308	Silicon transistor
TS618	FW 5324	4822 130 40142	Fairchild silicon transistor
TS619	BF 115	4822 130 40308	Silicon transistor
TS623	FW 5324	4822 130 40142	Fairchild silicon transistor

No.	*Type*	*Ordering number*	*Description*
TS701	BF 115	4822 130 40308	Silicon transistor
TS702	BF 178	4822 130 40299	Silicon transistor
TS703	BF 178	4822 130 40299	Silicon transistor
TS704	BCY 70	4822 130 40324	Silicon transistor
TS706	BF 115	4822 130 40308	Silicon transistor
TS707	FW 5435	4822 130 40186	Fairchild silicon transistor
TS708	BCY 70	4822 130 40324	Silicon transistor
TS709	BF 178	4822 130 40299	Silicon transistor
TS711	BF 178	4822 130 40299	Silicon transistor
TS801	ASZ 16	4822 130 40279	Germanium transistor
TS802	ASZ 16	4822 130 40279	Germanium transistor
TS803	2N3638	4822 130 40065	Fairchild silicon transistor
TS804	FW 5435	4822 130 40186	Fairchild silicon transistor
TS806	FW 5435	4822 130 40186	Fairchild silicon transistor
TS807	BDY 11	4822 130 40136	Silicon transistor
TS808	BDY 11	4822 130 40136	Silicon transistor
TS809	2N3638	4822 130 40065	Fairchild silicon transistor
TS811	BFY 52	4822 130 40462	Silicon transistor
TS901	BF 115	4822 130 40308	Silicon transistor
TS902	BF 115	4822 130 40308	Silicon transistor

MISCELLANEOUS PARTS

Item	*Ordering number*	*Description*
B401	ZZ 1000	Neon stabilizer
B402	E10 - 130 - GP	Cathode-ray tube
LA1...LA4	4822 134 40054	Lamp
LA5	6226D (CA)	Lamp
L51...L54	4822 157 50175	Coil
L251...L254	4822 157 50175	Coil
L601	4822 526 10025	Coil
T801	4822 146 20358	Transformer
T802	4822 142 60114	Transformer
VL1	4822 253 30021	Fuse 1A, delayed
VL1	4822 253 30025	Fuse 2A, delayed
VL2	4822 252 20001	Thermal fuse
—	4822 216 50128	Printed wiring board of vertical amplifiers complete with components
—	4822 216 50129	Printed wiring board of time base generator and horizontal amplifier, complete with components
—	4822 216 50131	Printed wiring board of high tension unit, complete with components
—	4822 216 50132	Printed wiring board of power supply unit, complete with components

C. PARTS OF THE MEASURING PROBES PM9326 AND PM9327 (Fig. 17)

Item	*Quantity*	*Ordering number*	*Description*
a	1	4822 320 10042	Proble cable 2 meters (6.5") for PM 9327
	1	4822 321 20087	Probe cable 1.15 meters (3.8") for PM 9326
b	1	4822 321 20096	Earthing flex 15 cm (6")
c	1	4822 321 20134	Earthing flex 30 cm (12")
d	1	4822 266 20015	Measuring probe 1 : 1 (black)
e	1	4822 268 10029	Measuring pin
f	1	4822 268 10039	Measuring hook
g	1	4822 210 70044	Attenuator probe 1 : 10 (grey)
h	1	4822 264 20009	Measuring clip
	1	4822 111 20155	Resistor

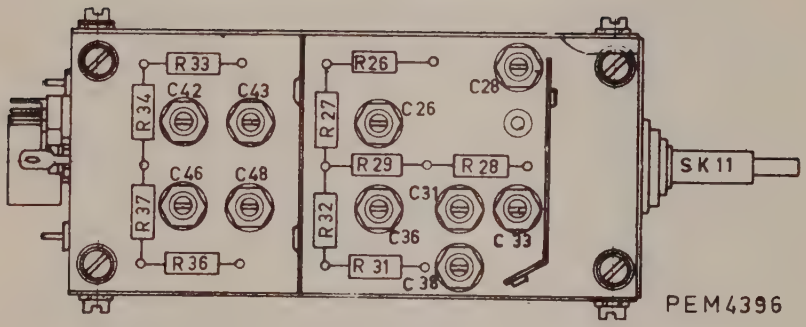


Fig. 25. Attenuator unit for channel A.

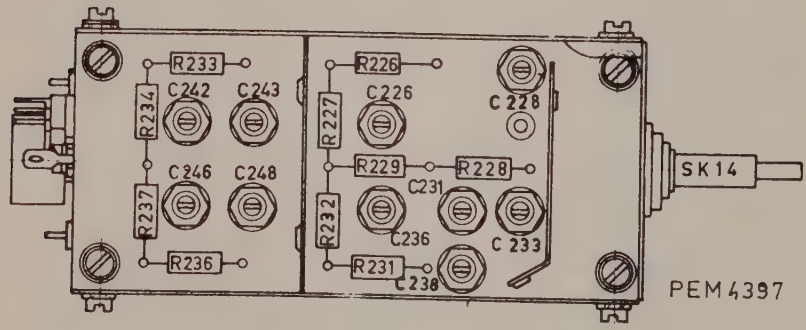


Fig. 26. Attenuator unit for channel B.

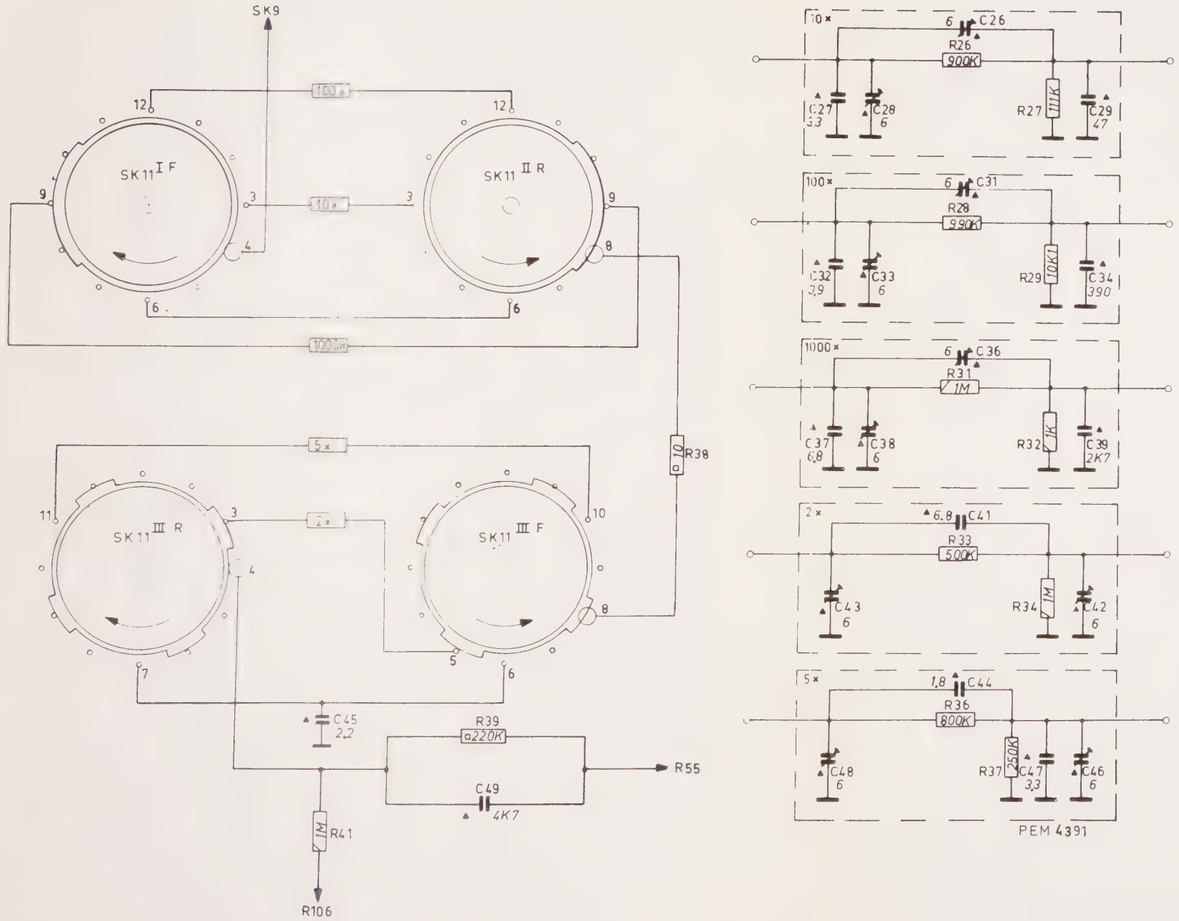


Fig. 27. Circuit diagram of the attenuator for channel A

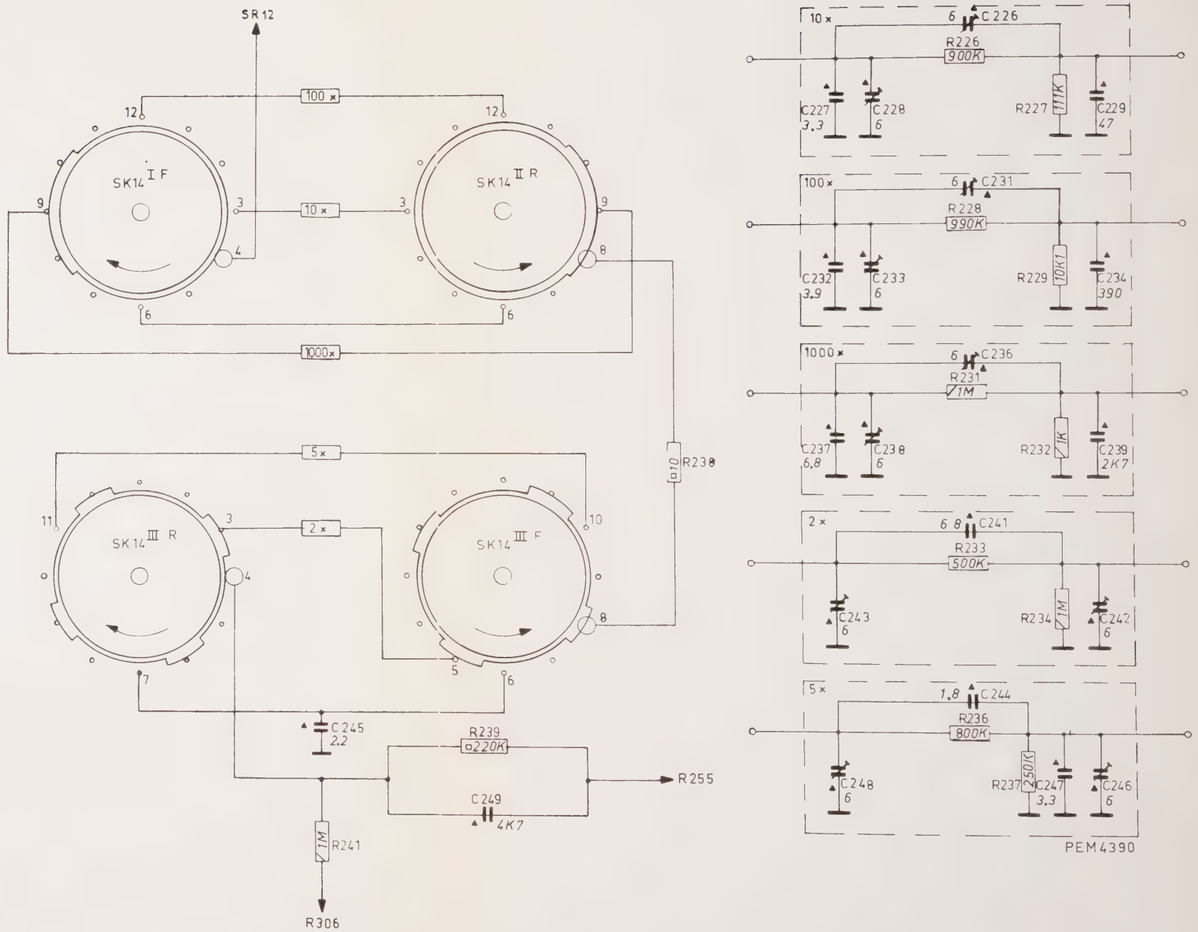


Fig. 28. Circuit diagram of the attenuator of channel B

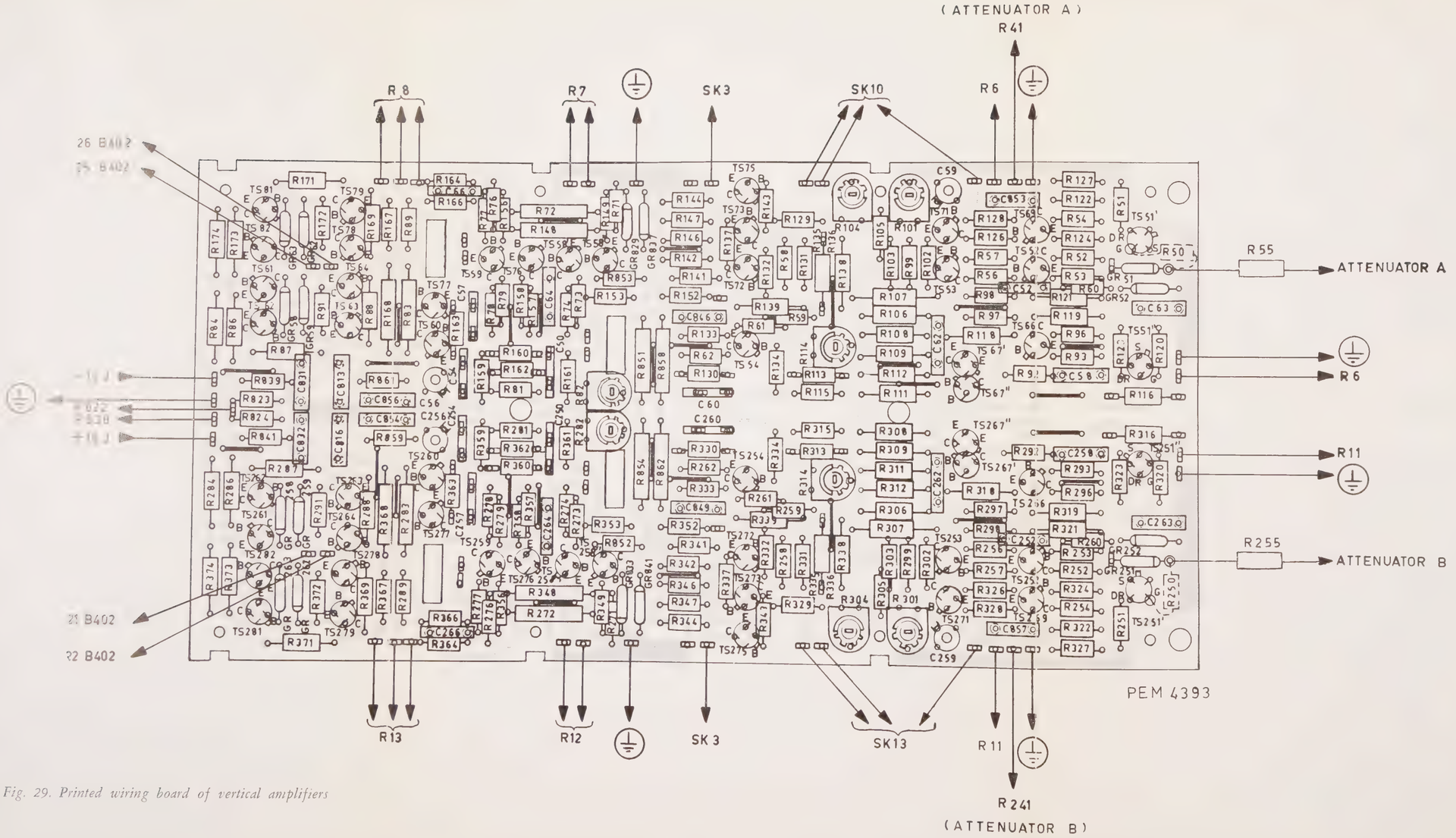


Fig. 29. Printed wiring board of vertical amplifiers

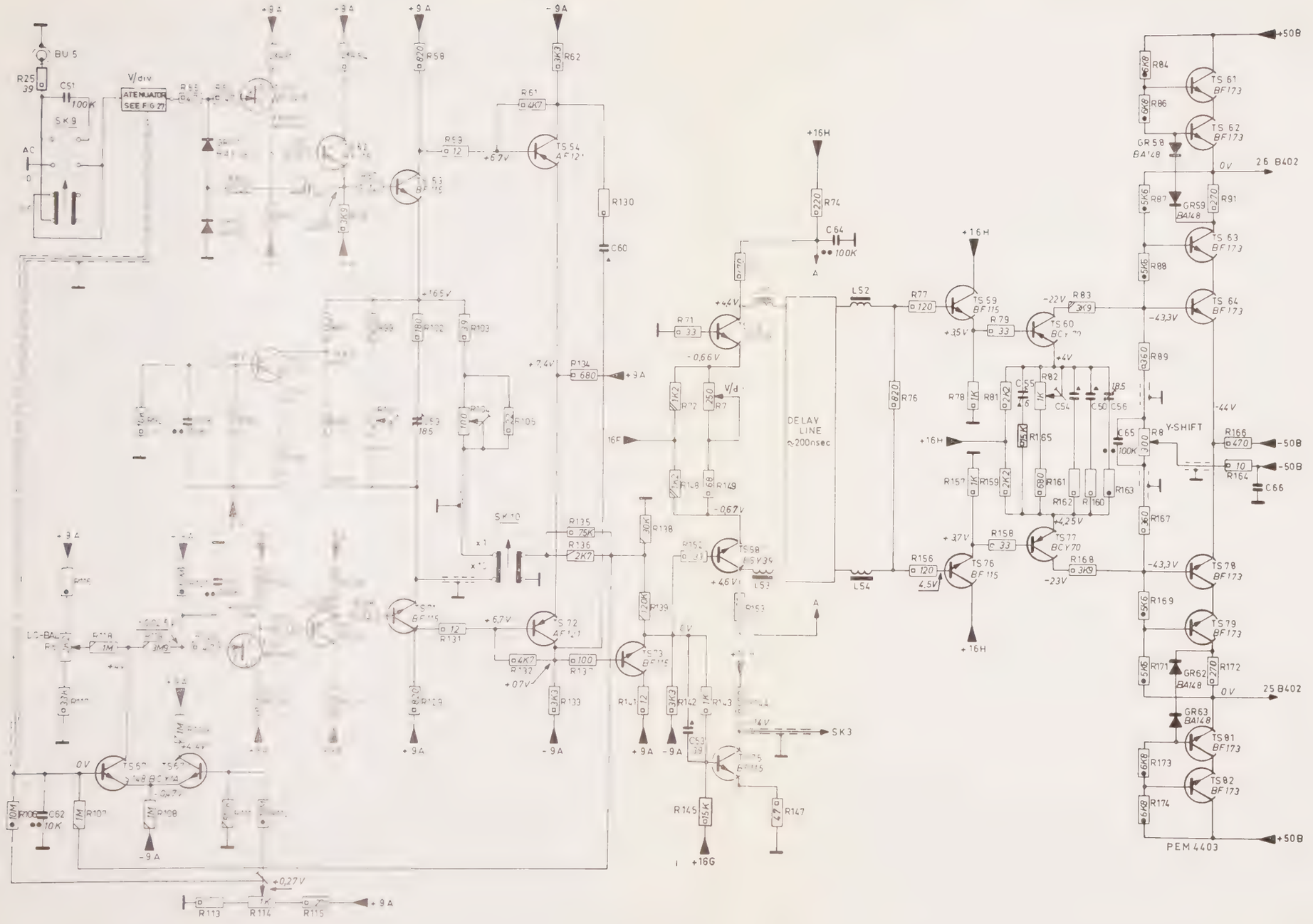


Fig. 30. Circuit diagram of vertical amplifier for channel A

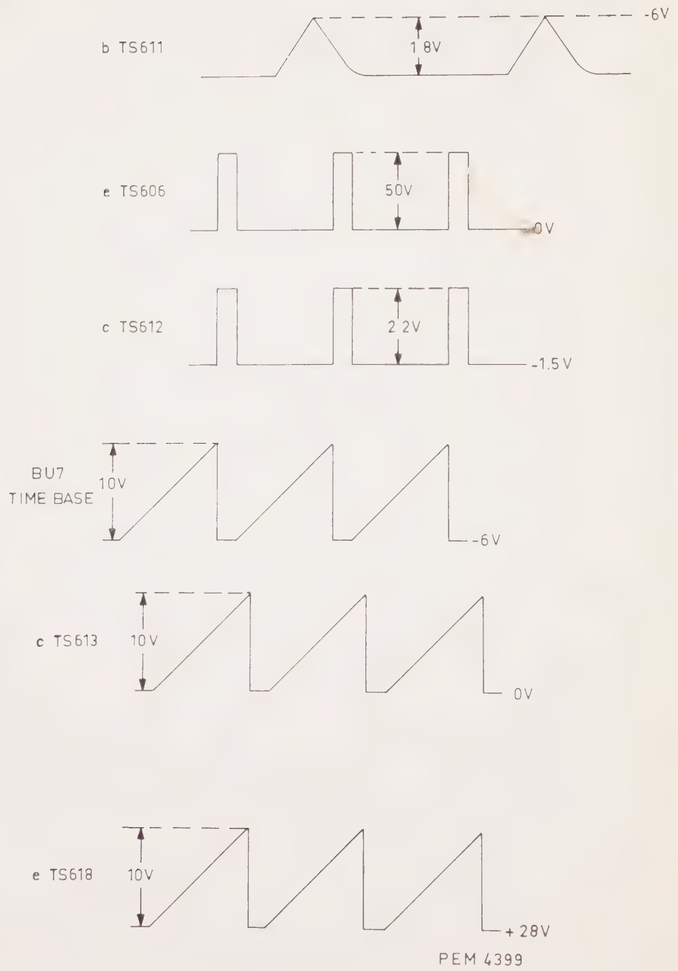


Fig. 32. Oscillograms

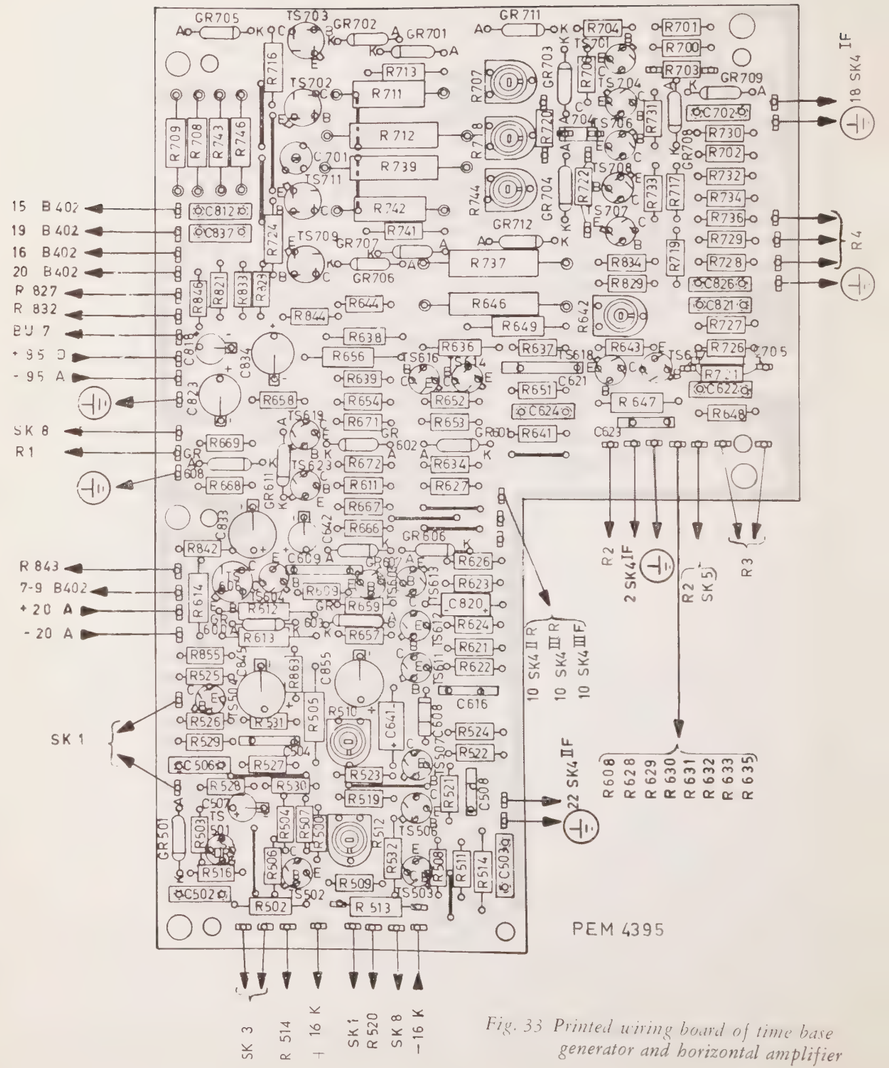


Fig. 33 Printed wiring board of time base generator and horizontal amplifier

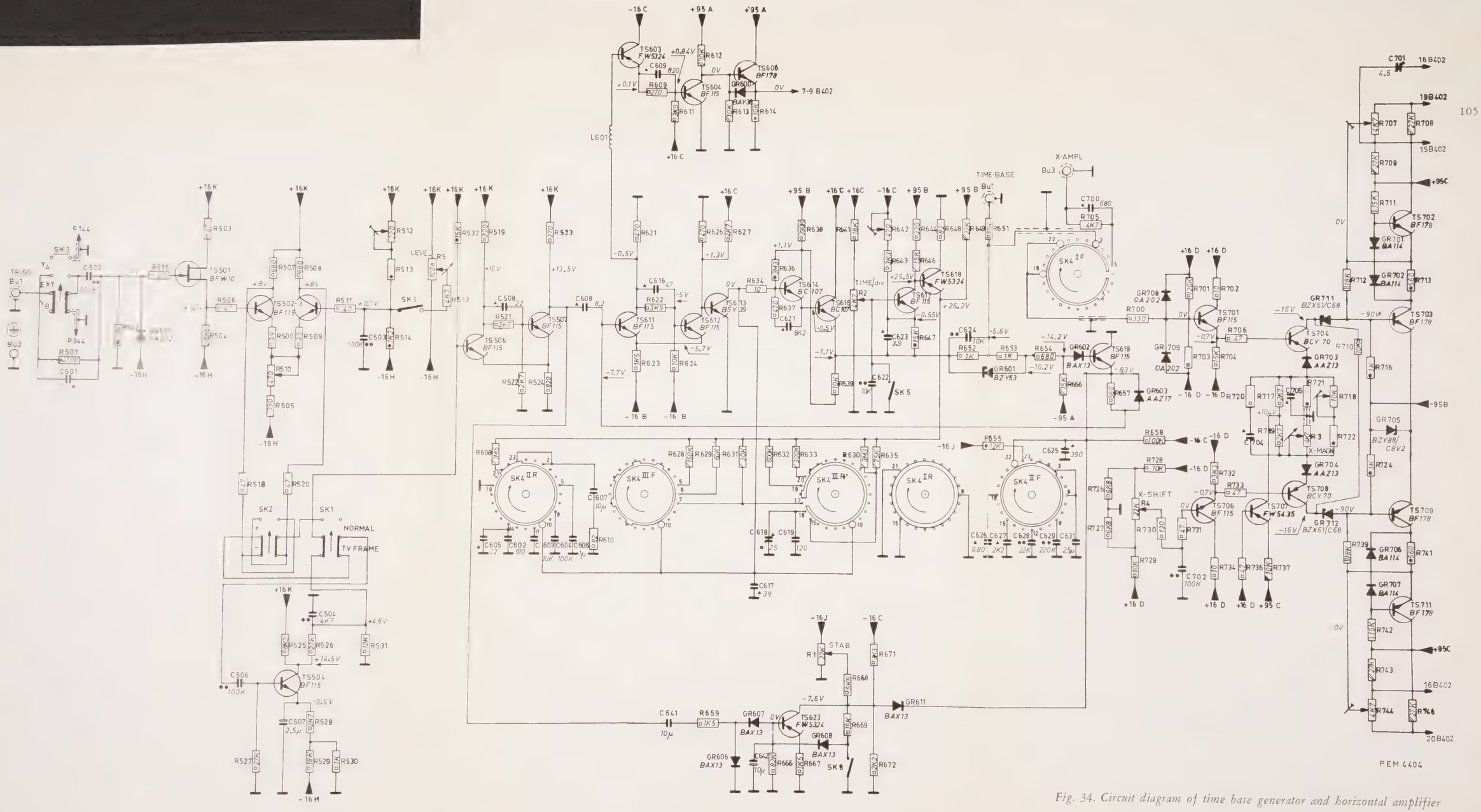


Fig. 34. Circuit diagram of time base generator and horizontal amplifier

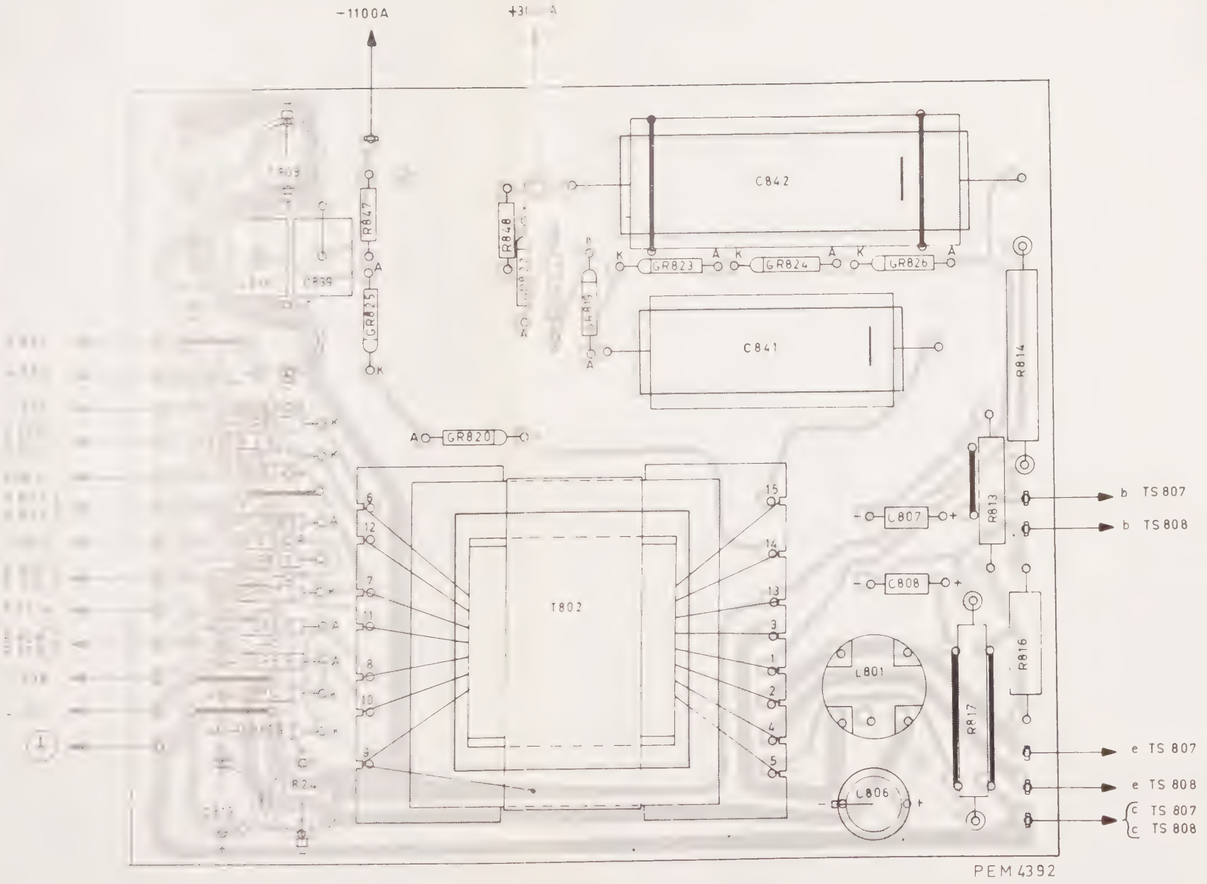


Fig. 35. Printed wiring board of H.T. unit

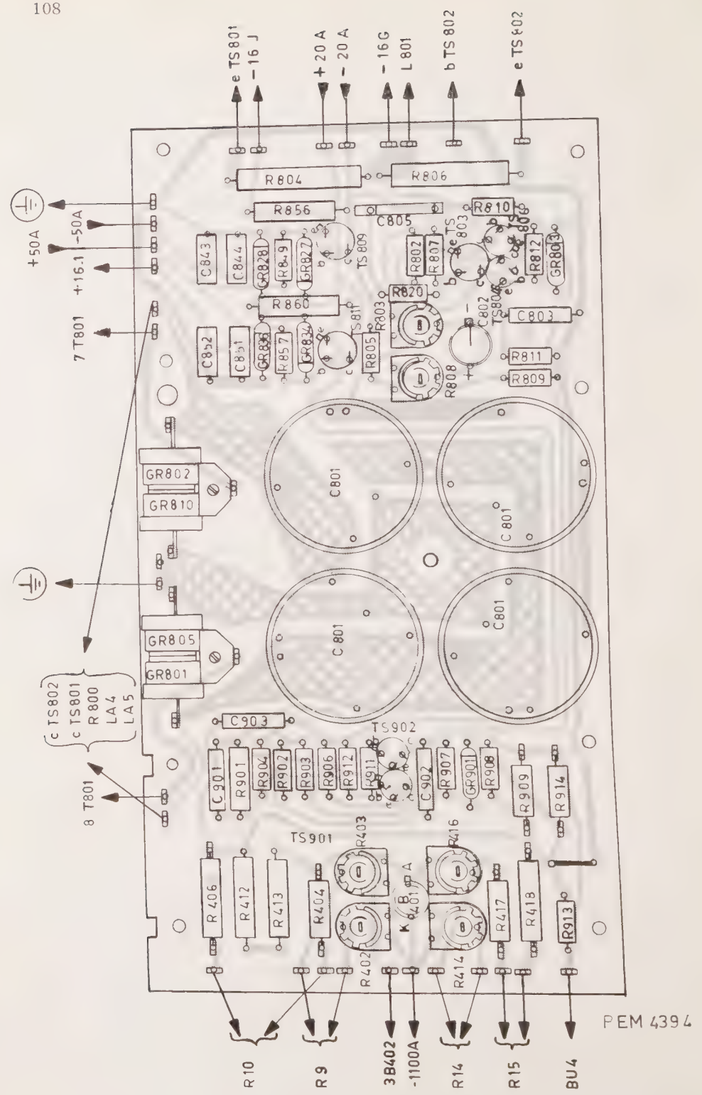
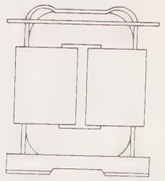
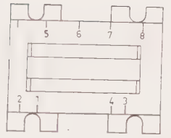


Fig. 36. Printed wiring board of supply unit

T801				
Coil	S1	S2	S3	S4
Volts	110	110	22.3	6.3
Turns	530	530	108	33

T801





MA5067

T802												
Coil	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Turns	2×2	2×5	2×5	2×2	15	11	7	7	11	15	380	140

PEM 4398

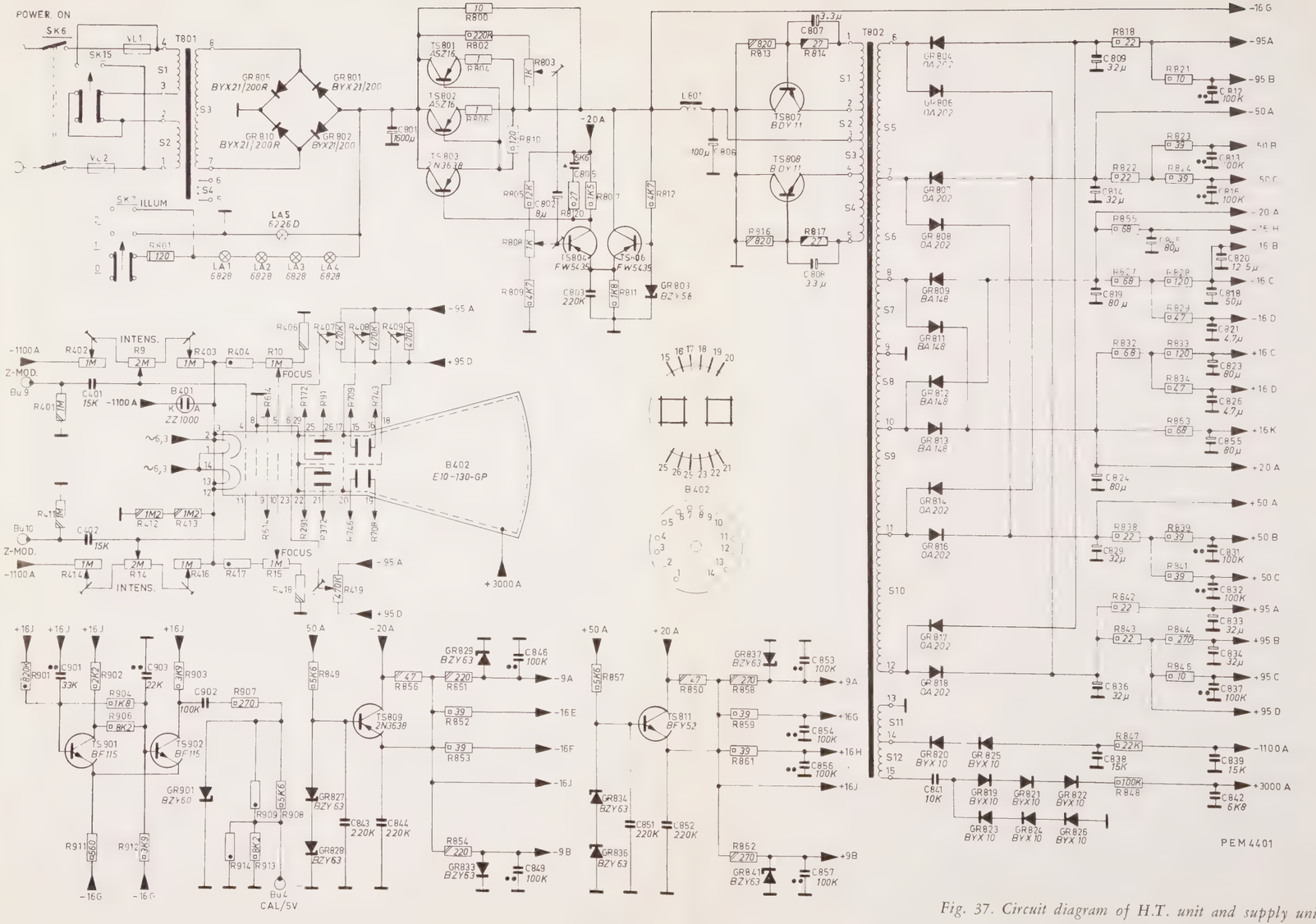


Fig. 37. Circuit diagram of H.T. unit and supply unit

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